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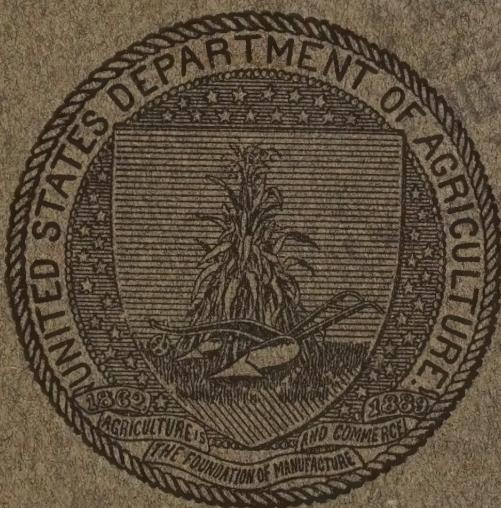
Issued September 10, 1909.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF PUBLIC ROADS,

LOGAN WALLER PAGE, DIRECTOR.

EXHIBIT OF THE
OFFICE OF PUBLIC ROADS.

ALASKA-YUKON-PACIFIC EXPOSITION.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1909.

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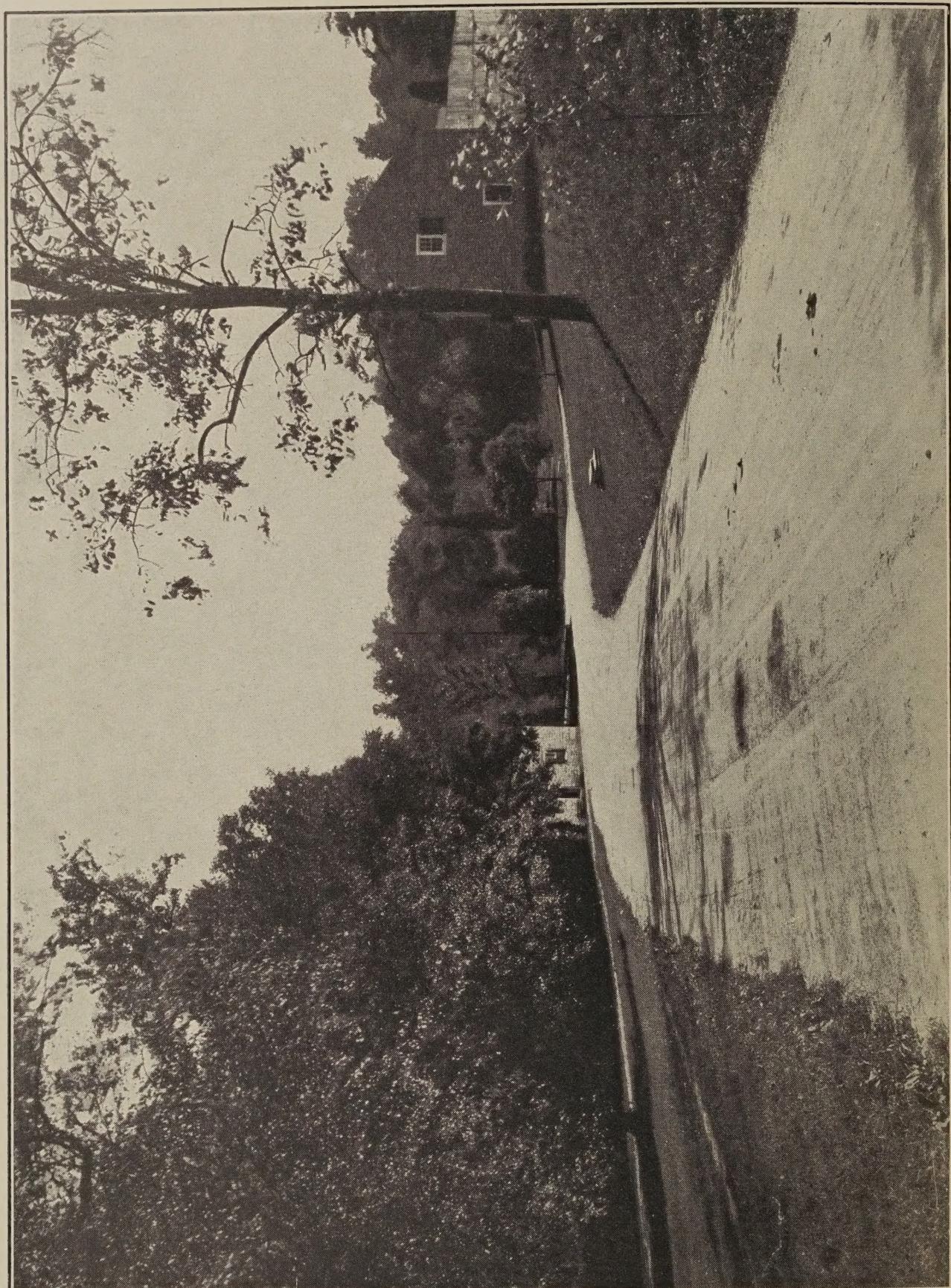
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MACADAM ROAD, ROCK CREEK PARK, DISTRICT OF COLUMBIA.

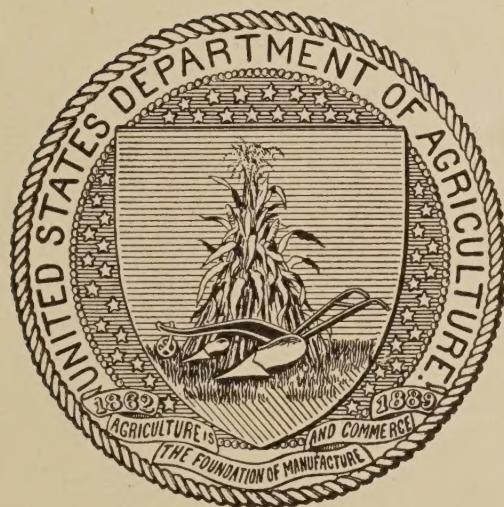
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF PUBLIC ROADS,

Washington, D. C., July 14, 1909.

SIR: I have the honor to transmit herewith a manuscript containing data explaining the exhibit of this office at the Alaska-Yukon-Pacific Exposition. The models of the various kinds of roads are explained in detail, and information is included about several different road machines also. I believe that this publication will be of a highly instructive nature, and it is therefore requested that it be printed as a separate bulletin of this office.

Respectfully,

L. W. PAGE, *Director.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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EXHIBIT OF OFFICE OF PUBLIC ROADS.

ALASKA-YUKON-PACIFIC EXPOSITION,

INTRODUCTION.

In assembling the very complete exhibit shown by the Office of Public Roads of the United States Department of Agriculture, those responsible for this feature of the Federal Government's contribution to the Alaska-Yukon-Pacific Exposition have sought to put on view such striking examples in miniature of model roads that visitors will not merely immediately appreciate the beneficent effects of perfected highways, but will at the same time be able to understand the methods of their construction.

Visitors will probably decide that the most striking feature of the display is the miniature model of a section of Rock Creek Park—the most beautiful of the many breathing spots in the District of Columbia. In this handsome miniature is shown not only some of Rock Creek Park's most picturesque landscape features but also some of the best examples obtainable of scientific road construction.

The model includes the famous Bowlder Bridge, the Pebble Bridge, and one other, with Rock Creek passing beneath them and winding in and out among the hills.

Picturesque, and yet practical, as is this handsome centerpiece of the exhibit, it will not attract as much attention from scientific road builders as will the miniature sections illustrating every type of road now in use.

Among the types thus illustrated, built to exact scale, are macadam, bituminous macadam, tarred macadam, Telford, slag asphalt, slag tar, oiled macadam, oiled earth, sand clay, burnt clay, and dragged earth.

Inasmuch as there are approximately 1,975,000 miles of earth road in the United States out of a total mileage of 2,150,000, a model of an earth road is appropriately first described.

EARTH ROADS.

(Plate II, fig. 1.)

This model illustrates the construction and maintenance of an earth road, and is built on a scale of $1\frac{1}{2}$ inches to the foot, or one-eighth full size, the various sections which go to make up the com-

plete model showing the roadbed and each succeeding step in the construction of this type of highway.

It will be noted that Section A shows the old and unimproved roadbed.

Section B illustrates a section of earth road under improvement with a road machine or grader, the width of the section shown being equivalent to 20 feet of finished surface.

Section C illustrates an earth road which, though surfaced by a road machine, has rutted under heavy traffic and is being maintained by the use of the split-log drag.

In the road illustrated by Sections B and C, the crown, or slope from center to sides, is equivalent to 1 inch to the foot. The surface of the section labeled "A" is characteristic of altogether too many earth roads, the center being several inches lower than the sides. This faulty condition makes it impossible for the water to run from the surface; and even if this were possible there are no roadside ditches to carry it away. In consequence, the road is usually full of puddles and cut up with ruts and mud holes.

Section B illustrates the use of a road machine or grader in opening roadside ditches and in shaping the road surface so it will shed water. This machine is equivalent to the labor of many men, and it does the work far better than can be done with shovels and picks.

The road machine should be used when the ground is damp and soft. In dry weather far more power is required to draw it than in wet, and clods when placed on the road in a dry condition make a most unsatisfactory surface, turning to mud with the first heavy rain. Because of these conditions, the road should be shaped in the spring or early summer, thus permitting the roadbed to pack and bake during the heated period in order that it may better hold up traffic during the winter rains.

An earth road should have a width of at least 20 feet—better still, 24 or 30. If the road be narrow there is a tendency to use but the narrow central portion, and wagons running in "the same old rut" soon create a water-holding depression. The surface drainage can be provided for by giving the road an average crown or slope from center to sides of 1 inch to the foot. On some soils the crown could be even less than that, but seldom greater. Unless the road runs through swampy or wet districts, side ditches, as shown in Model B, should be built. They can be made and maintained with a road machine, but care should be taken that they have a fall sufficient to carry the water along the side of the road. One use of the road machine will not keep the ordinary earth road in permanent repair. The machine should be used several times during the spring and early summer.

For continuous maintenance the split-log drag shown in Section C has been devised. This little model has been built to the same scale as the road model— $1\frac{1}{2}$ inches to the foot. It can be best made from a log 7 or 8 inches in diameter and from 6 to 8 feet long. The log should be carefully split and the halves fastened together with stakes, the flat sides vertical and facing to the front. The logs, though of the same length, are attached so that the end of the rear log is from 16 to 20 inches nearer to the center of the road than the first one.

An ordinary trace chain and set of doubletrees is then attached. When the horses move forward the drag should slide along the road at an angle of about 45° , the forward end being nearest to the ditch and thereby moving the earth toward the road center.

In the construction of this implement care should be taken to make it so light that one man can lift it. The best material is a dry red cedar log, though red elm and walnut are excellent, and box elder, soft maple, or elm willow are superior to oak, hickory, or ash. A board platform is usually placed on the cross stakes, helping to strengthen the implement and giving a place for the driver to stand. After a little practice a man will learn how to best distribute his weight so as to make the drag cut, spread, and pack the earth properly.

Dragging up one side of the road and down the other across the ruts is all that should be undertaken the first time, but this should be repeated after each heavy rain. As a mile of road can be dragged in a few minutes, the split-log drag provides a simple and inexpensive method of road maintenance. If it be used in conjunction with the road machine, fairly good earth roads can be secured at a nominal expense. If 50 cents a mile for dragging be considered a fair figure, and if the road be dragged a dozen times a year, it follows that road maintenance by this method will not cost more than \$6 per mile per annum. Some really remarkable results have been accomplished with the drag without the aid of the scraper. Farmers' Bulletin 321,^a "The Use of the Split-log Drag on Earth Roads," deals fully with this subject.

SAND-CLAY ROADS.

(Plate II, fig. 2.)

This model shows the sand-clay road construction and, like all other models, is on the scale of $1\frac{1}{2}$ inches to the foot.

Section A represents an unimproved sand road about 22 feet wide.

Section B represents an old sand road slightly rounded up to receive the clay, the center being 4 inches higher than the sides.

^a Farmers' bulletins will be sent free to any address in the United States on application to a Senator or Representative in Congress or to the Secretary of Agriculture, Washington, D. C.

Section C shows a portion of road covered with clay to a depth of 6 inches.

Section D illustrates the harrowing or mixing process.

Section E shows the completed road.

An inspection of this model shows that the bottom of the ditch of a completed road of this type would be about 1 foot lower than the road at the center, this giving an average slope of $1\frac{1}{2}$ inches to the foot.

In a generality of cases sand-clay roads are built on sandy foundations, and it is usually the practice to place the clay on the unimproved foundation, but better results will be obtained if the sandy foundation is given a slight crown; making the center from 4 to 6 inches higher than the side ditches. If this is neglected, more clay will be necessary to give the road the needed crown and that is expensive, especially if the material has to be hauled a considerable distance.

If the foundation is of clay the process may be reversed with satisfactory results, the clay road being plowed and harrowed, covered with from 4 to 6 inches of sand, and worked with a disk or tooth harrow when the ground is wet until both have been thoroughly mixed. When the mixing has been done the surface is brought to a crown with a road machine and covered with a thin layer of sand. After the first two or three rains another sand coat should be applied, this method producing a smooth, cheap, and satisfactory road suitable for light traffic.

Farmers' Bulletin No. 311, "Sand-clay and Burnt-clay Roads," gives full information on this subject, if more be desired.

GRAVEL ROADS.

(Plate III, fig. 1; Plate IV.)

The construction of a gravel road having shoulders is illustrated by this model. The model, being 30 inches wide between ditches, is equivalent to a 20-foot road, the traveled way representing a width of 12 feet.

Section A represents the prepared earth roadbed, showing a sub-grade with the center 10 inches higher than the bottoms of the side ditches and illustrating at the same time the method of constructing the shoulders so as to hold the gravel roadbed in position. These shoulders should be built upon the subgrade to a depth of about 4 inches.

Section B shows the first course of gravel, laid to a depth of 4 inches in the center and about 3 inches at the sides.

Section C represents the second course, the material being about 2 inches in depth at the center and $1\frac{1}{2}$ inches at the sides. The crown

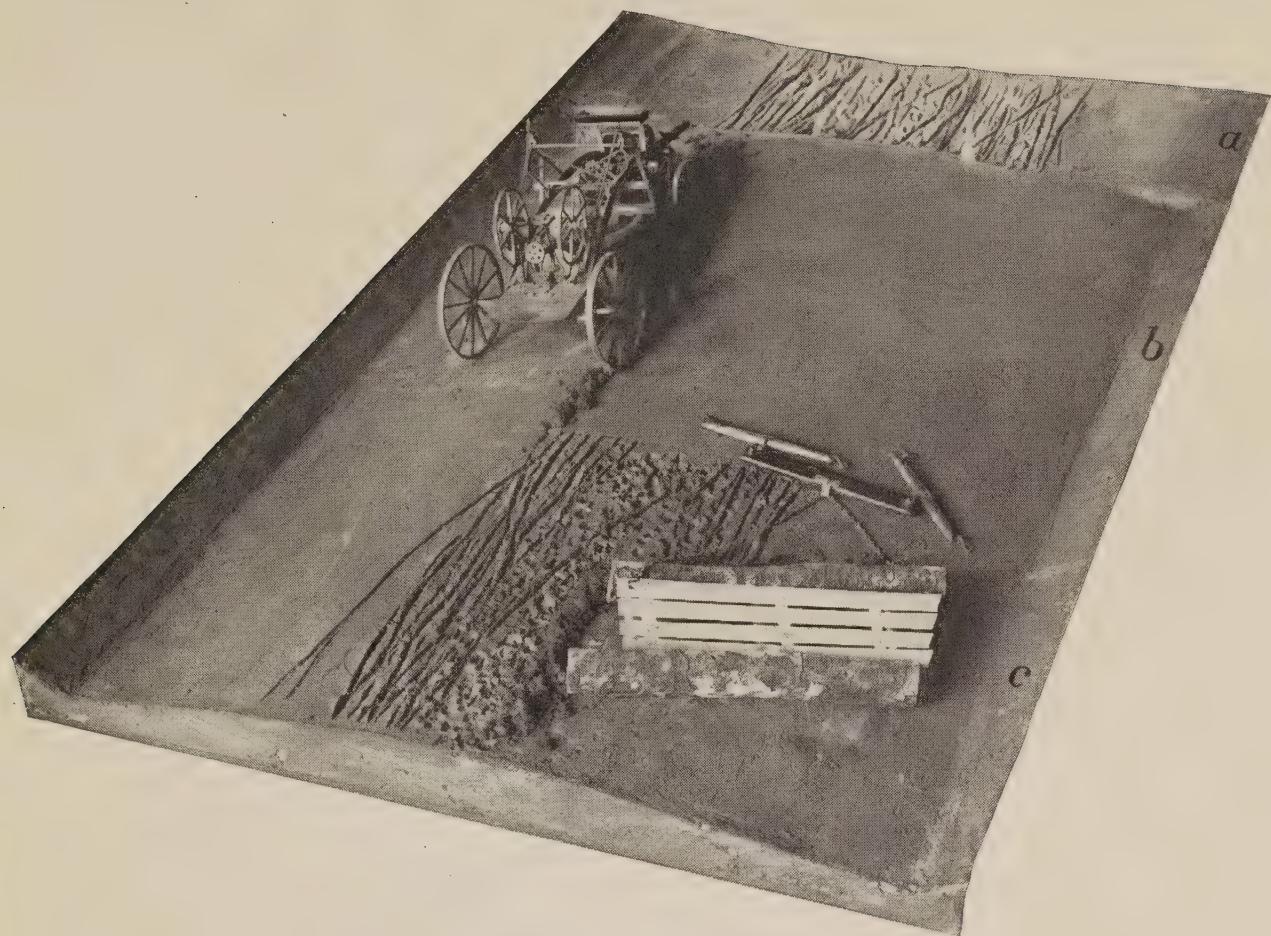


FIG. 1.—MODEL OF EARTH ROAD, SHOWING SPLIT-LOG DRAG AND ROAD GRADER IN OPERATION.

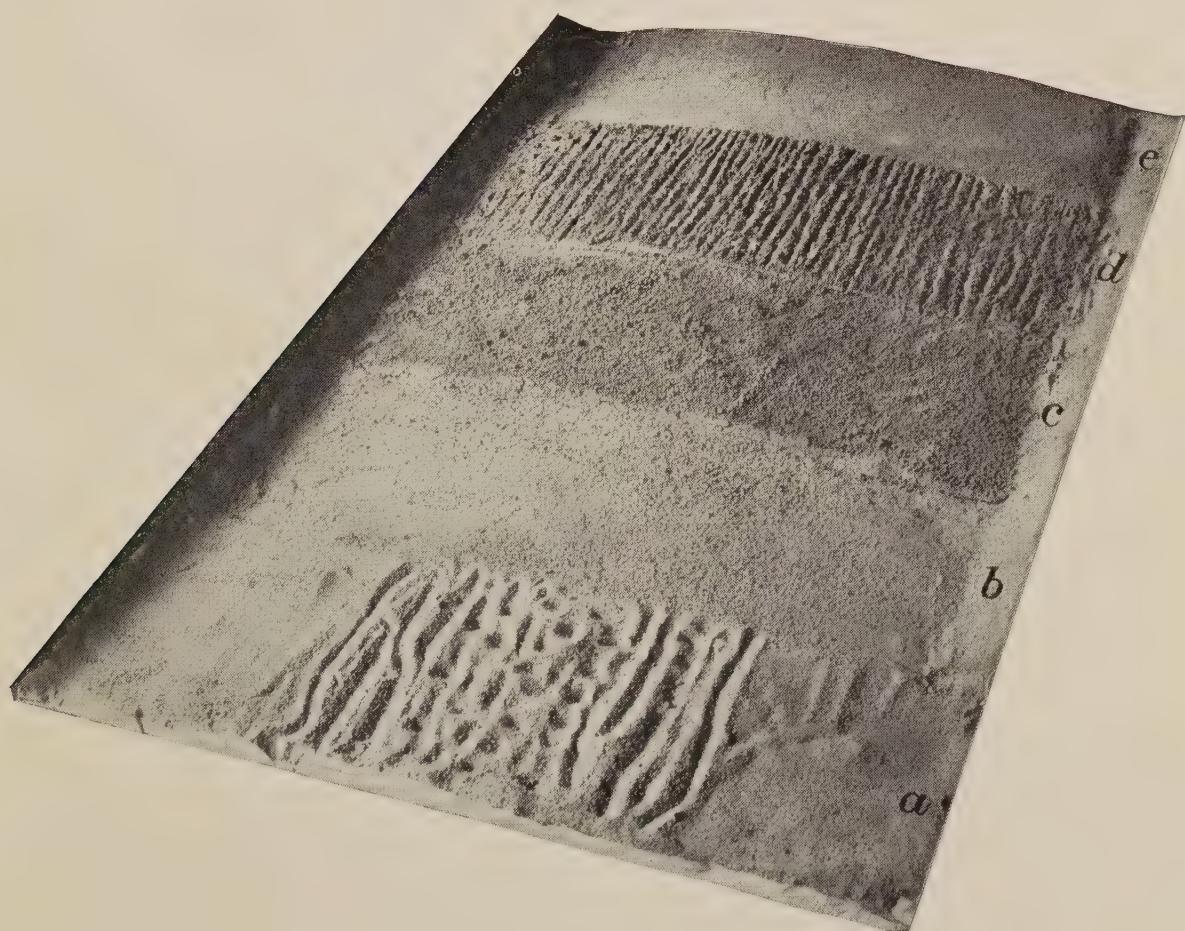


FIG. 2.—MODEL OF SAND-CLAY ROAD.

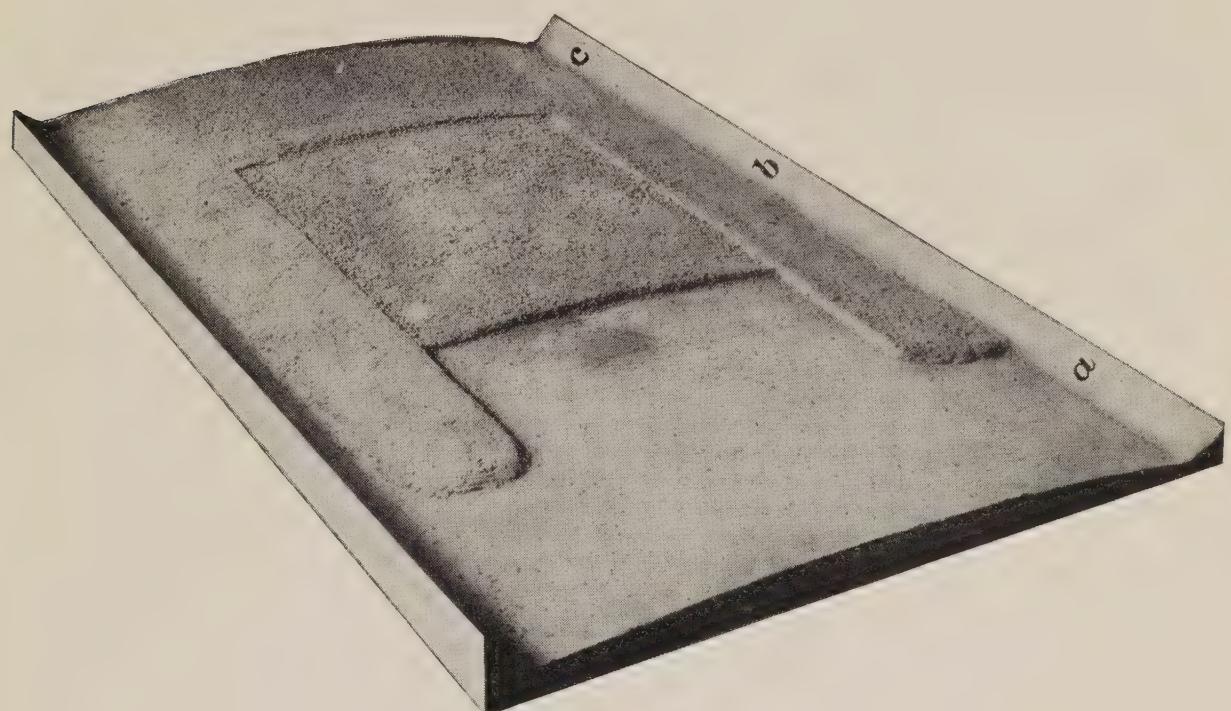


FIG. 1.—MODEL OF GRAVEL ROAD.

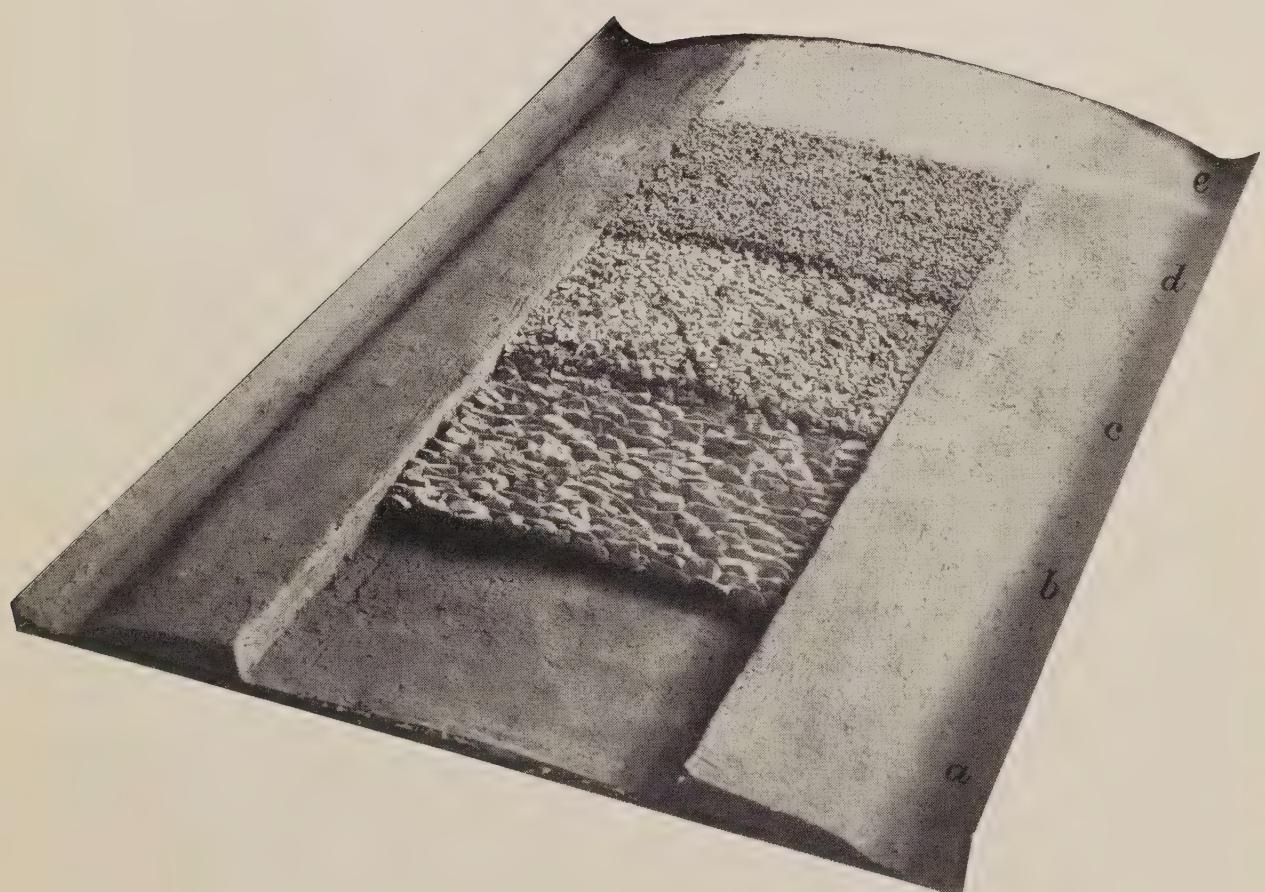
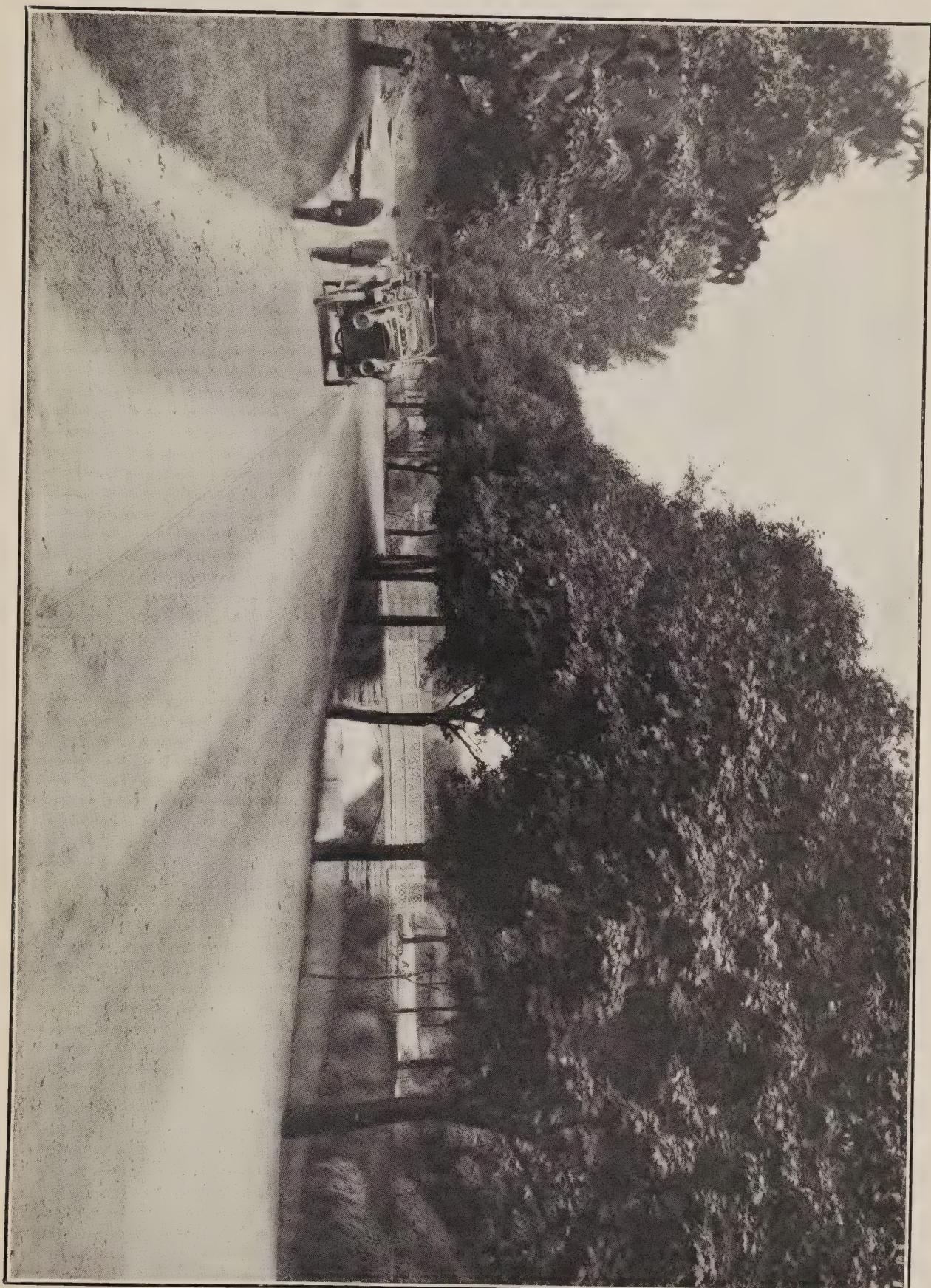


FIG. 2.—MODEL OF TELFORD ROAD.



GRAVEL ROAD IN PARK, RICHMOND, IND.

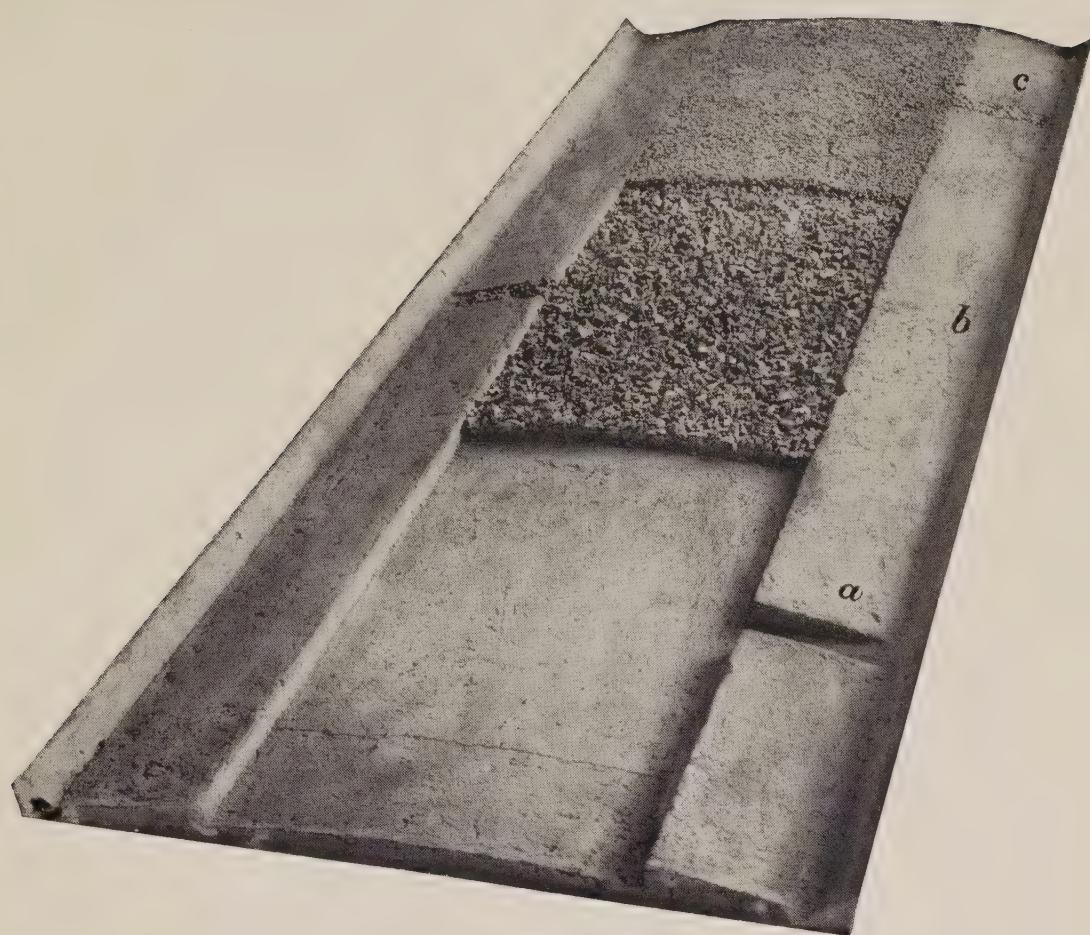


FIG. 1.—MODEL OF MACADAM ROAD.

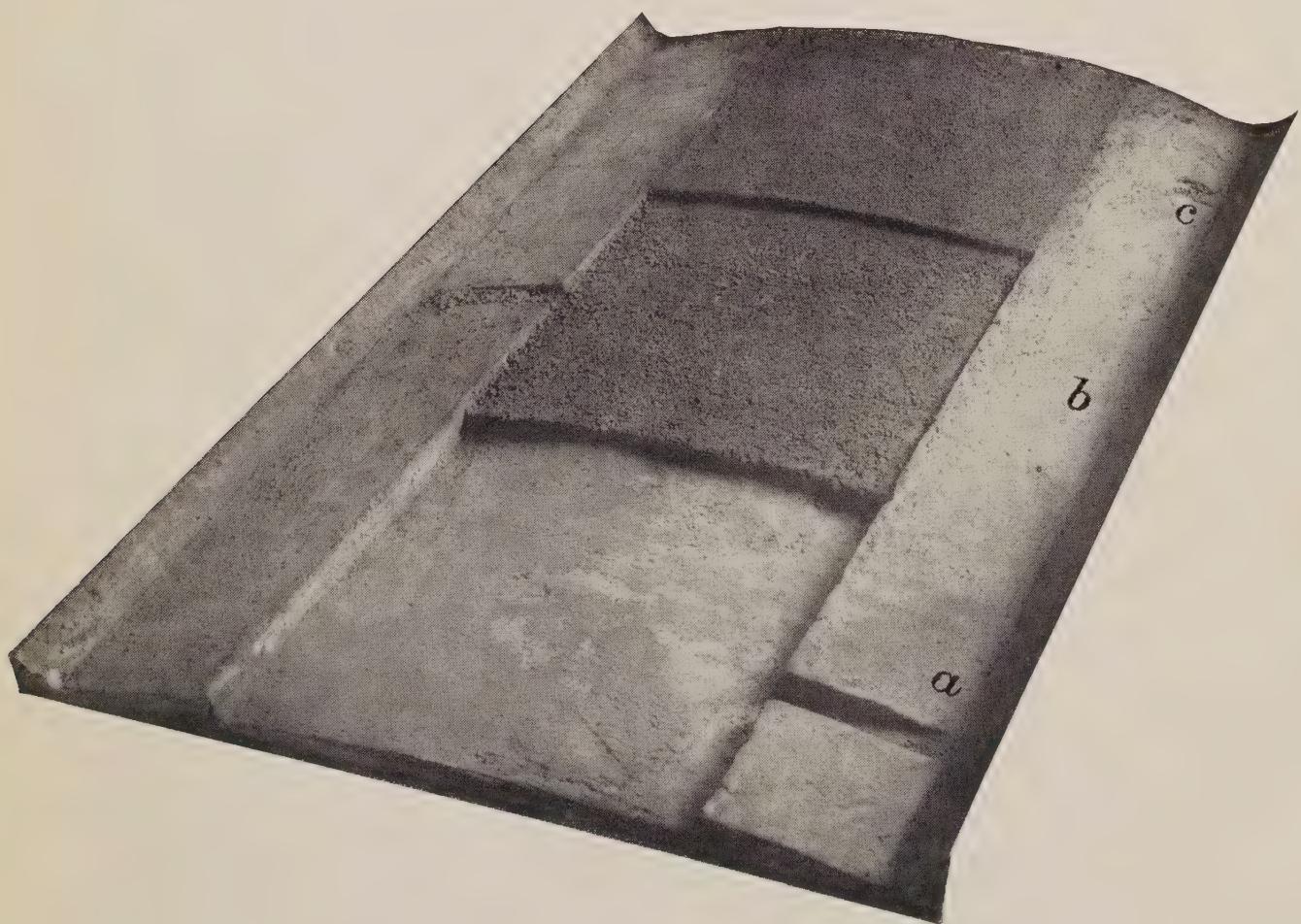


FIG. 2.—MODEL OF GRAVEL MACADAM ROAD.

or center of the road thus represented is about 6 inches higher than the surface of the road 6 feet from the center, which gives an average slope of 1 inch to the foot.

There is financial wisdom in thus preparing a foundation for a gravel road, because it saves material. If the gravel is simply spread on the unimproved roadbed far more will be required, and if it is spread without having shoulders constructed to hold it in place wagons will rut it and horses kick it away until in a short time the ditches will be full of gravel and the denuded road surface will be cut up with ruts.

With plenty of gravel available, it is wise to build shoulders from 3 to 6 feet in width and with a depth of from 4 to 6 inches at the inside edge, the depth of the gravel diminishing toward the side ditches. In some cases thin boards from 4 to 6 inches wide are placed along the inner edge of the shoulder to hold it in position until it is packed and the material has been spread. The material for the foundation course is then spread to a depth of from 4 to 8 inches in the center and from 4 to 6 inches at the sides. Creek or river gravel may be used for this course, but it is better to use bank or pit gravel, which possesses sufficient clay or earthy matter to bind it together.

When the foundation course has been prepared, the surface course should be spread to a depth of from 3 to 4 inches in the center and 2 to 3 inches at the sides. It should be of the very best quality and free from large pieces. In some instances it is advisable to screen the gravel into two or three sizes, using the larger sizes for the foundation course. All sand, clay, or earthy matter should be removed.

The best and cheapest method of screening gravel is by the rotary screen having holes of $2\frac{1}{2}$, $1\frac{1}{2}$, and $\frac{3}{4}$ inches. The best season for building gravel roads is in the spring, as they will then consolidate during the summer and be in better condition to withstand the fall and winter rains.

TELFORD ROADS.

(Plate III, fig. 2.)

Here is illustrated the construction of a Telford road having a width of 12 feet, with shoulders 4 feet in width, or 5 feet from the edge of the stone surface to the bottom of the side ditches.

Section A illustrates the prepared subgrade, 12 feet wide and excavated to a depth of 14 inches. The foundation being 5 inches higher in the center than at the sides gives the same crown as the finished surface.

Section B represents the Telford base, the depth of material being 7 inches.

Section C illustrates the No. 1 course of broken stone, laid to a depth of 4 inches.

Section D illustrates the No. 2 or second course, 3 inches deep.

Section E illustrates the finished road after being surfaced with screenings and stone dust, this last course adding nothing to the thickness of the road, as the fine material is washed and rolled firmly into the No. 2 course of broken stone.

In the preparation for a Telford road, the bed is excavated from the earth surface, as in the macadam road, side ditches and shoulder drains being built the same.

The radical difference between the Telford and the macadam road lies in the paved or hand-laid foundation of the first named, the stones forming a base from 5 to 8 inches thick.

The model of which this treats illustrates a Telford road with a base 7 inches thick, the paved foundation being about two-thirds the road's total thickness.

Telford's original method provided for a flat foundation, his pavements being deeper in the middle than at the sides, the stone in a 16-foot road being 8 inches deep in the middle and 5 inches deep at the sides. Modern practice, however, calls for stone of uniform depth, the surface of the base being parallel to the surface of the finished road.

In the construction of such a base as that illustrated, the various stones should be of the following sizes: Length, from 8 to 12 inches; depth, from 5 to 8 inches; thickness, at the base from 3 to 6 inches and at the top from 1 to 3 inches. They are to be laid lengthwise across the road on their broadest bases, every other course breaking joints as nearly as possible. Uneven points must be broken off and spalls used to wedge the surface together until a firm foundation has been secured.

Sections C, D, and E are built in the same manner as the macadam road, though not so thick, for roads possessing a Telford base do not require a macadam surface of more than from 4 to 6 inches after consolidation.

MACADAM ROADS.

(Plate V, fig. 1.)

This model illustrates a macadam road 12 feet wide and surfaced with 8 inches of consolidated stone, the shoulders being equivalent to 4 feet 4 inches.

Section A represents the prepared subgrade.

Section B represents the first course of broken stone, spread to a depth of about 5 inches.

Section C represents the second course, spread to a depth of 3 inches.

In the model the crown or slope of the foundation is the same as in the finished road, giving an average fall of three-fourths of an inch to the foot from center to sides.

In preparing for the construction of a road of this type it is advisable to roll the foundation thoroughly when the soil is damp so that all soft spots may be found and filled and the ground firmly and smoothly prepared for the first layer of stone. Shoulders are built on either side to hold the macadam in place, either by excavating the body of the old roadbed or by piling up the earth as the work progresses. The shoulders should never be less than 3 or 4 feet wide, if possible 6 or 8. If sufficiently wide and having a slope of not more than 1 inch to the foot, they will be used in dry weather for light traffic, thus relieving the macadam of fast travel, which causes it to ravel.

In every case the bottoms of the side ditches should be lower than the road foundation to insure speedy drainage. If the road is built of clay or heavy soil shoulder drains should be built at low places to lead water from the foundation. The drains are filled with crushed rock or gravel and the side ditches should be shallow, but wide, their construction being based on the volume of water they may be expected to carry.

The No. 1 crushed rock for the foundation course may vary in size from $1\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter, but never larger. The depth of this course must depend upon conditions. If built on light gravelly soil where light traffic may be looked for, a depth of 3 or 4 inches is sufficient, but for heavy soils and heavy traffic the course should be from 4 to 6 inches deep after rolling. For roads 12 feet wide or less the depth of material should be uniform throughout, but if the road be from 14 to 16 feet the total depth of both courses may be reduced to 6 inches for an 8-inch road and 4 inches for a 6-inch road.

After the foundation course has been thoroughly rolled from the sides to the center, the second course, varying in size from $\frac{3}{4}$ to $1\frac{1}{4}$ inches, is applied. While rock of inferior quality may be used for the foundation course, nothing but the best hard and tough rock should be used for the surface. It should not only be able to resist the pounding and grinding of traffic, but should have a high cementing value so that the fine particles will bind the surface into a water-shedding crust.

The final course of screenings does not add to the depth of the road, which when completed should be flush with the earth shoulders. The total depth of roads of this type should vary from 4 to 12 inches, construction being governed by local conditions, but the average depth of such roads in the United States is not more than 6 inches.

COMPLETED MACADAM ROAD.

(Plate VI.)

By this model is illustrated a completed macadam road with a 12-foot macadam surface and shoulders 4 feet 4 inches wide, to total road width of 20 feet 8 inches.

There is wisdom in building wide roads, for they expose a larger surface to traffic and require less care than narrow ones, the traffic being more evenly spread because of the greater area of road surface. The initial cost of wide roads is of course greater than that of narrow ones, but there is a saving in maintenance, especially if the narrow road be so scant that teams can not pass and must travel in the same rut.

In spreading the No. 2 or surface-bonding course, the stone may vary from three-fourths of an inch down to dust. It is not necessary to separate the dust from the screenings unless there be an excess of dust. If too much is used the road will be sloppy in wet weather and dusty in dry, and if there is not a sufficient quantity of screenings the road will quickly ravel, especially under fast automobile traffic.

Care and judgment must be exercised in determining the proper amount of screenings and also in spreading them. One thin layer should be spread and rolled, and after it has been thoroughly sprinkled and rolled another should be spread. By continuing this process until all voids are filled and the surface has been thoroughly consolidated a waterproof surface will be secured.

On this model is shown a miniature steam roller, the presence of this tiny facsimile of its gigantic prototype emphasizing the importance of road rolling. In the long run better and cheaper work can be done with a steam than with a horse roller, and one may also be used to advantage in road repair work.

If the road surface becomes uneven or rutted it can be spiked by teeth placed in the wheels of the roller. Then the surface can be leveled off and resurfaced with another course of No. 2 stone, after which it may be rolled and again treated with screenings.

Farmers' Bulletin No. 338, "Macadam Roads," gives much additional information on this subject.

GRAVEL MACADAM ROADS.

(Plate V, fig. 2.)

This model illustrates the construction of a gravel macadam road, built in layers after the macadam method, the miniature representing a 12-foot road with 4-foot shoulders on either side, the shoulder depth being 4 inches.

Section A shows the prepared subgrade, the excavation representing a width of 12 feet and a depth of 8 inches.

Section B represents the first course of gravel, spread to a depth of 5 inches.

Section C shows the second course of finer gravel, equivalent to a depth of 3 inches in the completed road, the shoulders represented being equivalent to a width of $4\frac{1}{3}$ feet. The crown or slope of the foundation is 5 inches higher in the center than at the sides, an average of three-fourths of an inch to the foot.

In constructing this type the foundation should be thoroughly rolled before any gravel is spread, in order that all depressions may be found and filled.

Side ditches should be lower than the lowest part of the road foundation, and drains should be cut through the shoulder and filled with gravel if the road be built of clay or other heavy soil. They should be placed 200 or 300 feet apart, or at all low places, their locations being governed by conditions. Creek or river gravel from which clay or soil has been removed may be used for the foundation course, provided gravel possessing sufficient binding clay is used for the surface course.

In frequent instances good results are secured by separating the gravel into three sizes, as for a macadam road, using the larger sizes for the foundation and the finer for the second and the binder courses. The gravel should be wet when spread and rolled. The surface course should be composed of material not larger than from 1 to $1\frac{1}{2}$ inches in diameter, and enough clay or fine gravel should be added to it to bind it together. If too much clay be present, however, the road will be muddy and sticky in wet weather and dusty in dry.

A judicious use of the split-log drag will keep this type of road in repair at a small cost.

MACADAM ROADS WITH V-SHAPE FOUNDATION.

(Plate VII, fig. 1; Plate VIII.)

Here is illustrated a 12-foot macadam road with a V-shaped foundation which is constructed of field stones or boulders.

Section A shows the prepared subgrade ready to receive the foundation stone. The depth of shoulders is 1 foot and the center of the foundation is 10 inches below the bottom of these shoulders, the slope toward the center being equivalent to $1\frac{2}{3}$ inches to the foot.

Section B represents the completed foundation.

Section C represents the first course of macadam.

Section D represents the regular No. 2 course of macadam laid to a depth of 3 inches.

Section E shows the completed surface of a macadam road bonded with screenings and dust.

The V-shaped macadam road has been constructed by the Massachusetts Highway Commission as a substitute for the Telford method. It is especially good in heavy clay soils or in low swampy places where the foundation can not be depended upon to hold up the regular macadam road.

In this type of road the foundation is sloped from the sides to the center rather than from center to sides, as in all other methods of road construction, and shoulder drains are cut at low places and filled with bowlders or gravel. Through these drains the water which makes its way to the foundation is conveyed to the side ditches.

Field stones, bowlders, or broken stone secured from excavations in the road are used in building the foundation, the larger pieces being placed in the bottom and the smaller ones on the surface. The total depth of the foundation is from 18 inches to 2 feet in the center and from 4 to 8 inches at the sides. The foundation is given a slope or crown and the crushed stone is then placed on the road, as illustrated by Plate V, figure 1, and Plate VI.

In the completed road the crown appears to be higher than in the ordinary macadam road, but this is on account of the deep side ditches, the crown really being only about 5 inches higher at the center than at the sides—an average of about three-fourths of an inch to the foot.

In the model the depth of the first and second courses is equivalent to 8 inches, but in actual construction the depth of these two courses frequently amounts to no more than 4 to 6 inches.

BURNT-CLAY ROADS.

(Plate VII, fig. 2.)

This model illustrates the building of a burnt-clay road, the model being the equivalent of a road 20 feet between ditches, with a burnt-clay surface 16 feet wide.

Section A shows the old roadbed plowed up and after ridges 18 inches high and 4 feet apart have been thrown across the road.

Section B shows the method of stacking the clay and wood preparatory to burning. A layer of 4-foot cord wood is placed across the ridges and lengthwise of the road. Then a second layer is laid across the road, and on this a few clods of clay are placed. A third layer of wood is then placed with the sticks running lengthwise along the highway, and 18 inches of clay from the roadside ditches is placed upon it. Then the flues between the ridges are filled with bark and light wood and fire is applied. It will require from twenty-four to thirty-six hours to complete the burning of one section.

Section C shows a piece of road after it has been burned and before being spread and rolled. It will be noted that the burning removes the stickiness or plasticity of the clay and leaves it in hard clinker-like lumps.

Section D illustrates the finished road, smooth and firm and well crowned, the slope being 1 inch to the foot.

The burnt-clay road, which is confined to the Mississippi Delta States where stone and gravel is scarce and "gumbo" or "buckshot" clay plentiful, is never muddy in winter unless mud be carried to it from other roads.

Farmers' Bulletin No. 311, "Sand-clay and Burnt-clay Roads," gives full information about this type of highway, if more be desired.

OILED EARTH ROADS.

(Plate IX, fig. 1.)

This model shows the construction of an oiled earth road, the type now popular in the California orange belt.

Section A shows the dusty road before improvement.

Section B shows the road plowed to a depth of 6 inches.

Section C illustrates the application of oil to the plowed road.

Section D shows the road after being harrowed and the oil worked into the loose soil.

Section E shows the completed road after having been thoroughly rolled, the crown representing a slope of three-fourths inch to the foot.

In preparing this road for its final treatment it is necessary first to bring the surface to the same general crown as for an ordinary earth road and then to plow and harrow it until all clods are broken up. After that has been done the hot oil is applied from a tank wagon at the proportion of 1 gallon to the square yard, the oil being thoroughly mixed with the earth by means of a harrow and a road grader. To facilitate proper mixing it is frequently advantageous to apply a considerable quantity of water.

After this first mixing the road is again plowed and a second and then a third application of oil is made. If, when the finished road is being rolled and compacted, any excess oil shows on the surface, it should be taken up with fresh earth. In compacting the oiled earth road it is wise to use a tamping roller, which consists of a drum carrying a large number of blunt-headed spikes in its circumference. This device compacts the road from the bottom up rather than from the top down, as is done by an ordinary roller.

TREATED MACADAM ROADS.**TARRED OR OILED ROADS.**

(Plate IX. fig. 2.)

The surface treatment of an old macadam road with tar or oil is shown by this model.

Section A shows the macadam surface before treatment.

Section B shows the surface swept free from dust and detritus.

Section C shows the application of hot tar to the swept surface at a ratio of from three-tenths to seven-tenths gallon per square yard.

Section D shows the final application of sand to the tarred surface, thus completing the treatment.

In applying the tar or oil a number of methods may be adopted—pouring by hand or through the use of a sprinkling wagon. The liquid should be thoroughly broomed into the old surface before the sand is applied to insure perfect cohesion. Before any application of oil or tar be made all loose material should be removed and the road surface be absolutely dry. Enough sand should be applied to take up what excess of tar may be left on the surface.

TARRED ROADS—PENETRATION METHOD.

(Plate X. fig. 1.)

The construction of a tar macadam road built according to the penetration method is here shown—the model being equivalent to a macadam surface 12 feet wide.

Section A represents the prepared subgrade, excavated to a width of 12 feet and a depth of 6 inches.

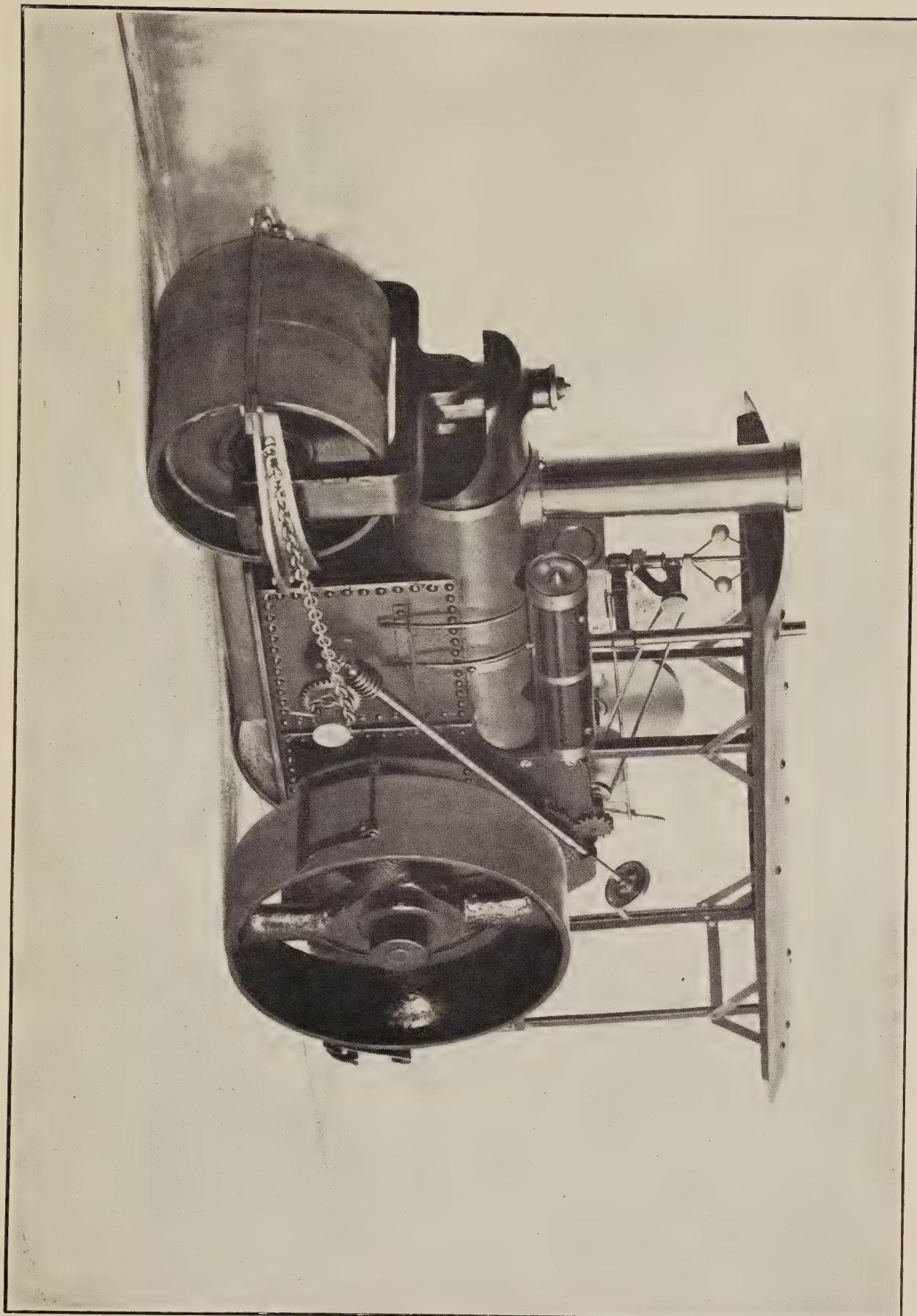
Section B represents the first course of No. 1 stone, placed to a depth of 4 inches.

Section C represents the second course of No. 2 stone, spread to a depth of 2 inches.

Section D shows the application of tar to the No. 2 course.

Section E shows the application of screenings, which completes the road surface, the crown of the finished road representing an average fall of one-half inch to the foot.

The construction of this road, to a certain point, is the same as an ordinary macadam road—Nos. 1 and 2 courses being so built. Before the screenings are applied, however, hot tar is flushed into the No. 2 course at the ratio of from 1 to $1\frac{1}{2}$ gallons to the square yard. When the screenings have been spread the road is rolled until thoroughly compacted and it is then ready for traffic.



MODEL OF MACADAM ROAD, WITH EXACT MODEL OF ROAD ROLLER IN OPERATION.



FIG. 1.—MODEL OF MACADAM ROAD WITH V-SHAPED FOUNDATION.

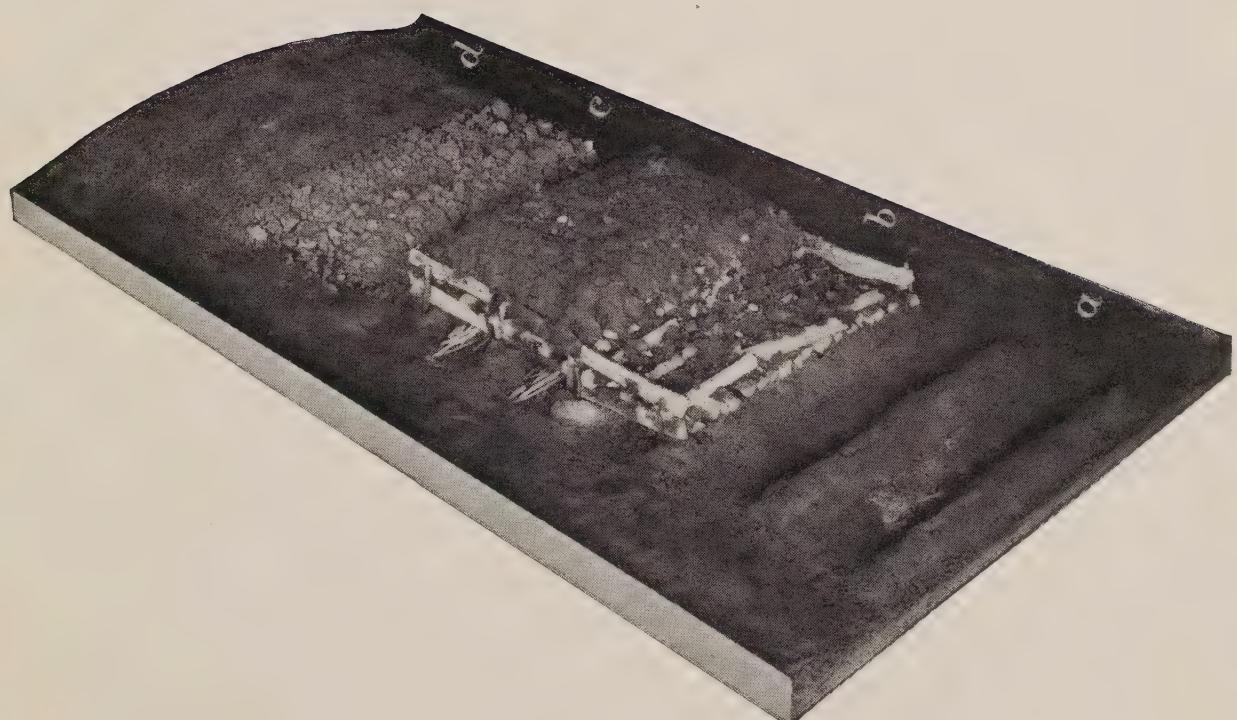
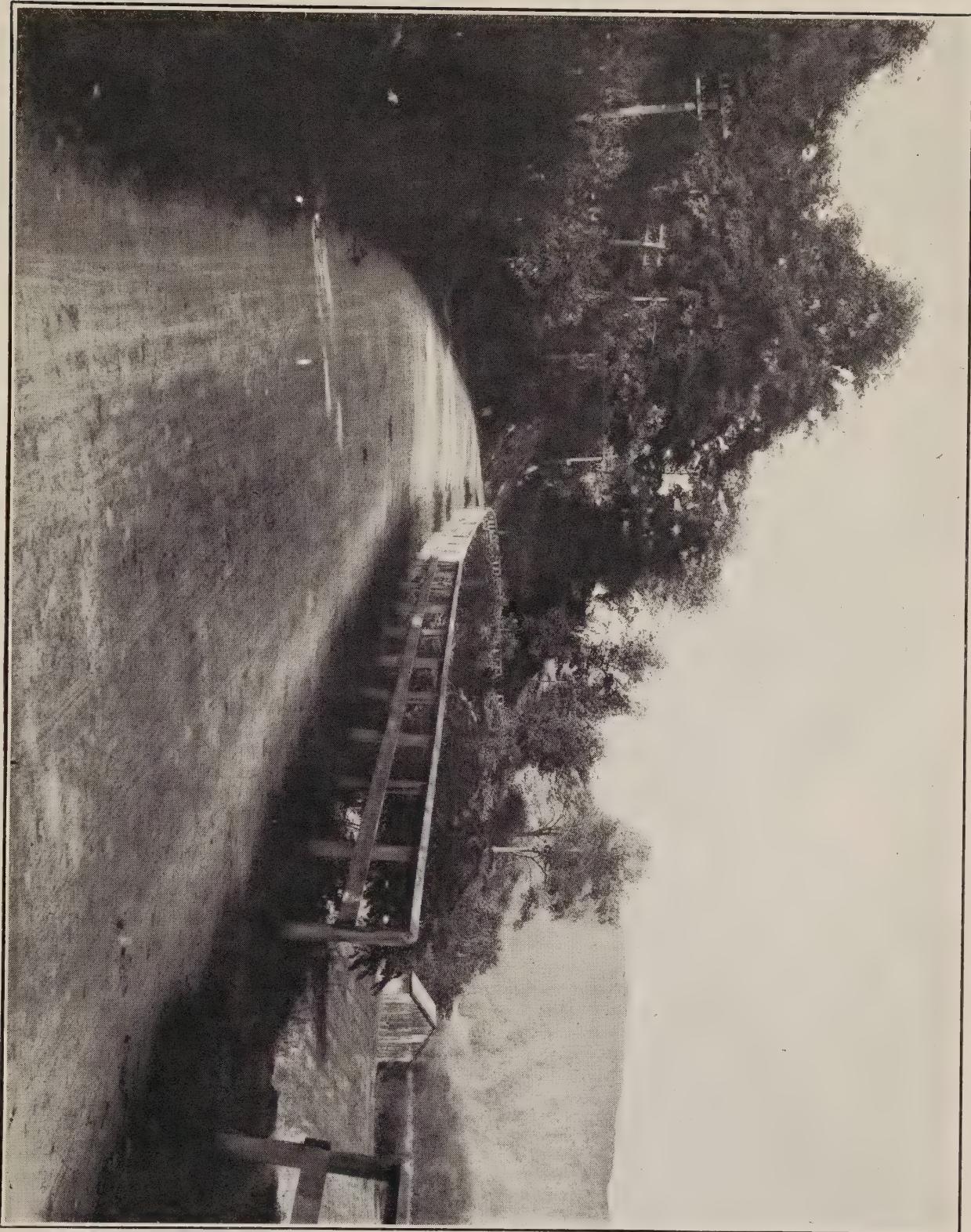


FIG. 2.—MODEL OF BURNT-CLAY ROAD.

MACADAM ROAD WITH V-SHAPED FOUNDATION AT RUSSELL, MASS.



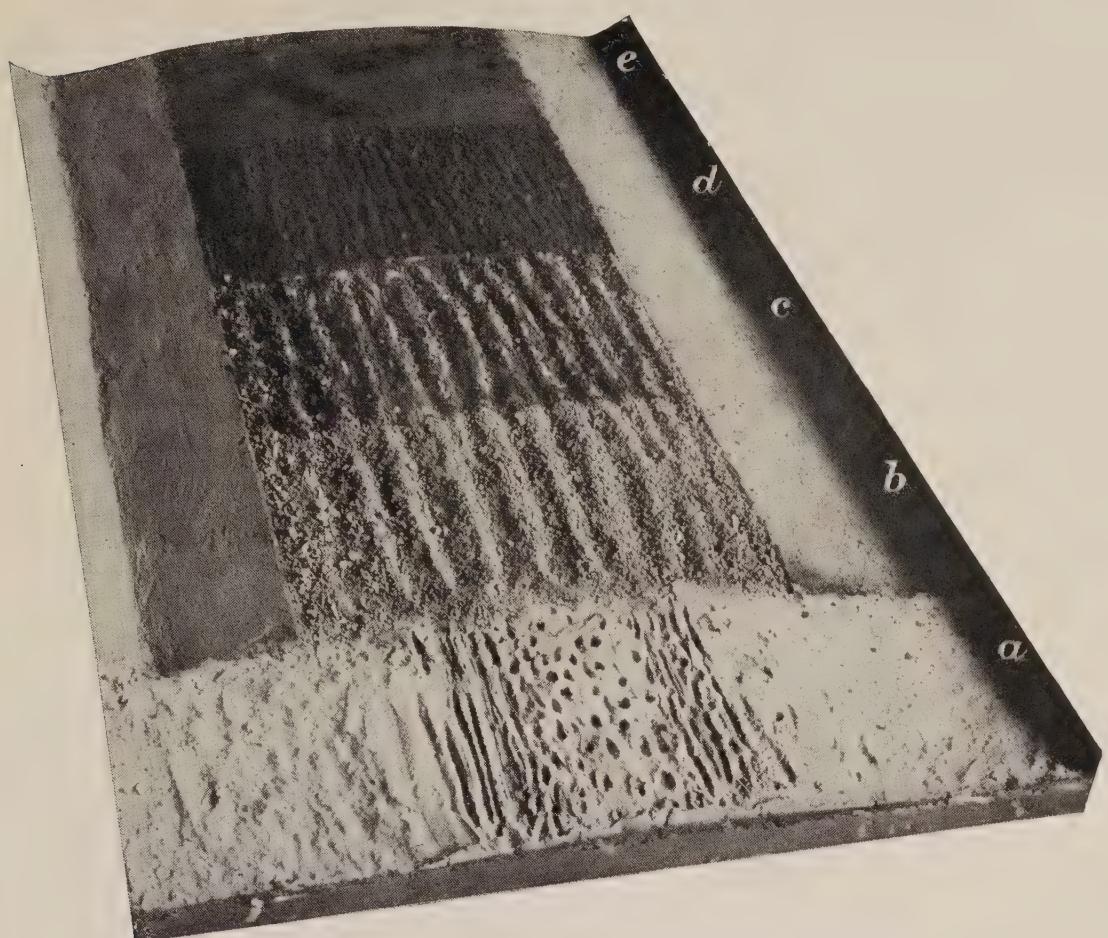


FIG. 1.—MODEL OF OILED EARTH ROAD.

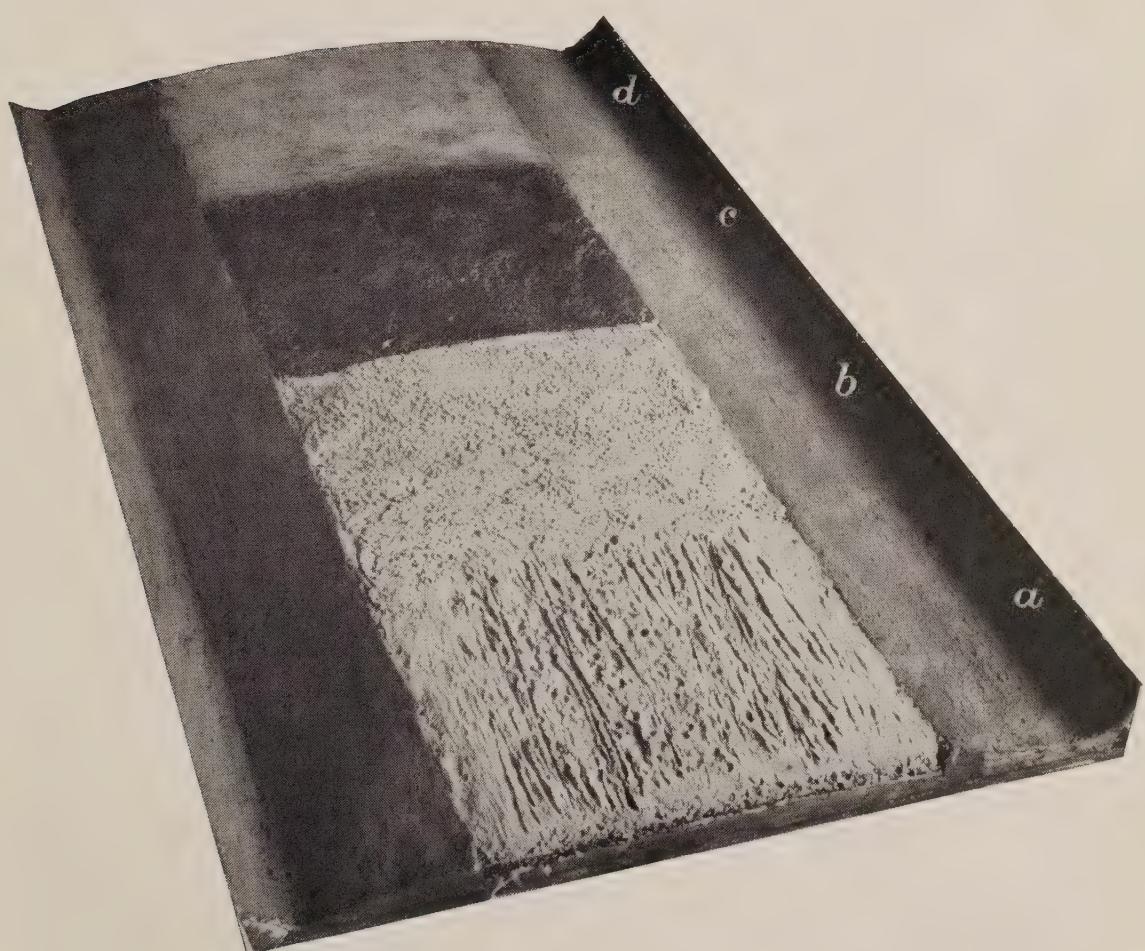


FIG. 2.—MODEL OF TARRED MACADAM ROAD.

TARRED ROADS—GLADWELL METHOD.

(Plate X, fig. 2.)

This model illustrates a tarred macadam road built according to the Gladwell method and, like the other models, is on a scale of $1\frac{1}{2}$ inches to the foot, the macadam surface being equivalent to a width of 12 feet.

Section A shows a No. 1 course of stone which has been placed on the subgrade as in the ordinary macadam construction.

Section B represents the application of 1 inch of tarred screenings.

Section C represents the application of 2 inches of No. 2 stones.

Section D shows that layer painted with hot tar.

Section E shows the application of a final coat of screenings. These being rolled down add nothing to the thickness of the road, which, when thus completed, is crowned with a slope of one-half inch to the foot.

The peculiar departure that makes this road distinctive begins after the first course of No. 1 stone—the foundation course—has been laid. On that the course of tarred screenings is spread and then the layer of No. 2 stone, and when rolled the screenings are forced downward into the foundation course and upward into the surface course, thus binding both together. Rolling should be continued until the tarred screenings appear on the surface, and then a light sprinkling of screenings or tarred sand may be applied to fill the surface voids.

The final operation is the painting of the No. 2 course with hot tar at the ratio of from one-half to seven-tenths gallon a square yard and the application of dry screenings to take up all excess of tar and to give a proper finish.

TAR, OIL, OR ASPHALT ROADS.

(Plate XI, fig. 1.)

This model illustrates the construction of a tar, oil, or asphalt macadam road, having a macadam surface 12 feet wide.

Section A illustrates the prepared subgrade excavated to a depth of 6 inches and a width of 12 feet.

Section B represents the first course of No. 1 stone, placed to a depth of 4 inches.

Section C represents the second course of bitumen-covered stone, spread to a depth of about 2 inches.

Section D represents the application of about a one-fourth-inch layer of bitumen-covered sand, which being rolled firmly into the surface voids adds nothing to the thickness of the road.

Section E shows the application of an extremely light coat of stone dust, which is the finished application and which should leave the road with a sloping crown of one-half inch to the foot.

The subgrade is as in other macadam roads, the course of bitumen-covered stones being prepared by applying sufficient hot bitumen to cover a graded mineral aggregate when mixed. This graded aggregate is composed of No. 2 stone and stone ranging in size from three-fourths of an inch to dust in proportions of 960 pounds to 350 pounds.

Before applying the bitumen-covered sand, this course must be thoroughly rolled and the sand then applied in such quantities that it will fill the surface voids and bring the surface to a smooth and even condition.

The final coat of stone dust is merely applied for the purpose of taking up any excess of bitumen and of giving the road a pleasing appearance.

TAR-SLAG ROADS.

(Plate XI, fig. 2.)

This model shows the construction of a tar-slag macadam road, the slag surface being equivalent to a width of 12 feet.

Section A represents the subgrade, prepared as for the ordinary macadam road, being excavated to a width of 12 feet and a depth of 6 inches.

Section B represents the first course of broken slag, placed to a depth of 4 inches.

Section C represents the second course of broken slag, the slag being the regular No. 2 size, coated with tar before spreading, and placed to a depth of 2 inches.

Section D represents the No. 2 slag, which has been rolled and painted with tar.

Section E shows the application of a light covering of slag screenings which, being rolled into the surface voids of Section D, adds nothing to the road thickness, the road crown when finished representing an average slope of about one-half inch to the foot.

The method employed in making this road is similar to that in an ordinary macadam road except that no water is used and the second course is covered with hot tar before being applied, the slag and tar being mixed either by machinery or by hand. The amount of tar will vary with the quantity of slag, though usually averaging about 5 per cent of the weight of the slag.

When the course represented by Section D has been rolled, it is painted with a light coat of tar to insure a perfect adhesion of the coat of screenings, which is last applied and thoroughly rolled.

ROADS IN ROCK CREEK PARK, DISTRICT OF COLUMBIA.

(Plate I; Plate XII, fig. 1.)

This is a model in miniature of a portion of the handsome Rock Creek Park at the National Capital, and it shows the relationship of roads and bridges to rugged topography.

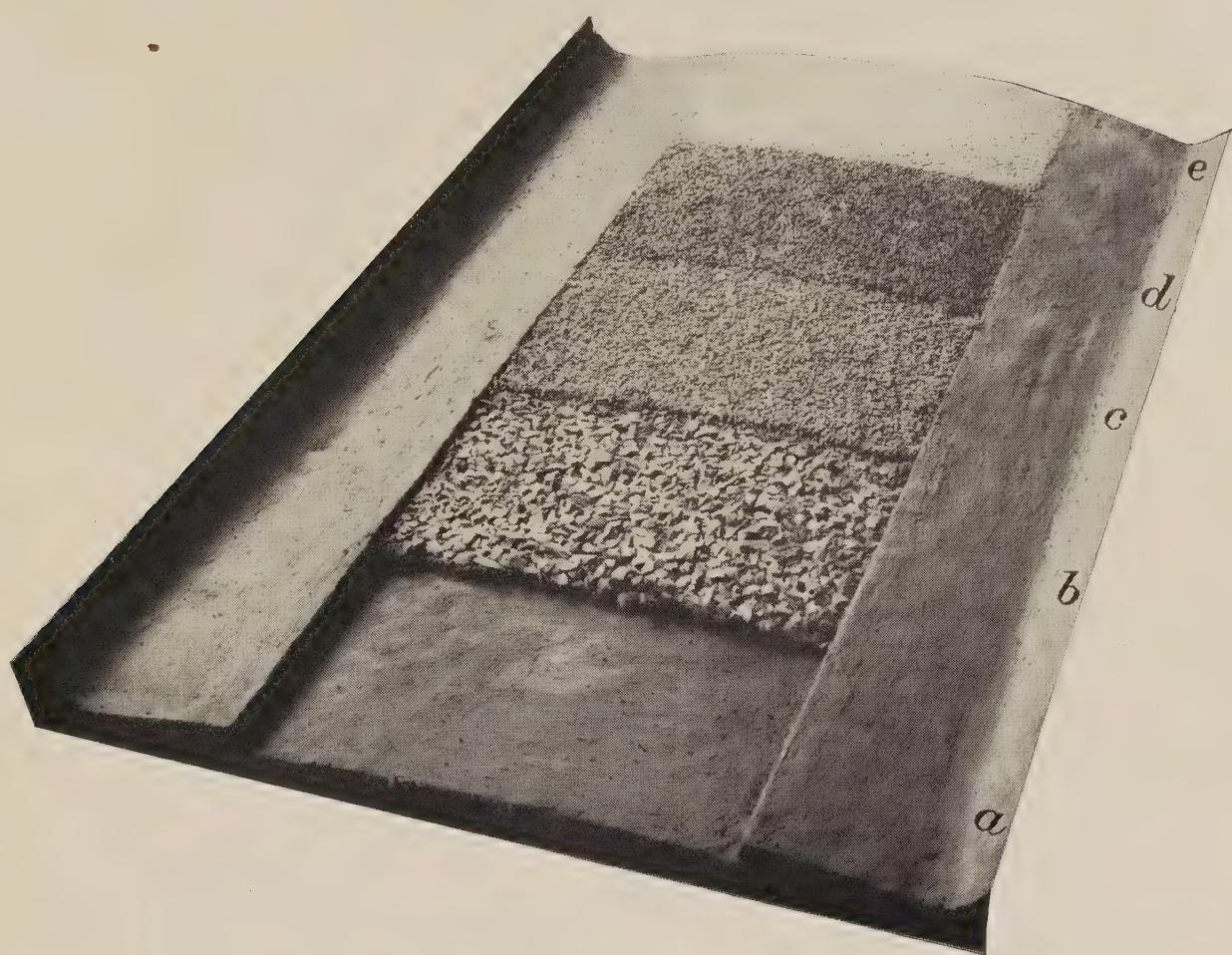


FIG. 1.—MODEL OF TARRED MACADAM ROAD—PENETRATION METHOD.

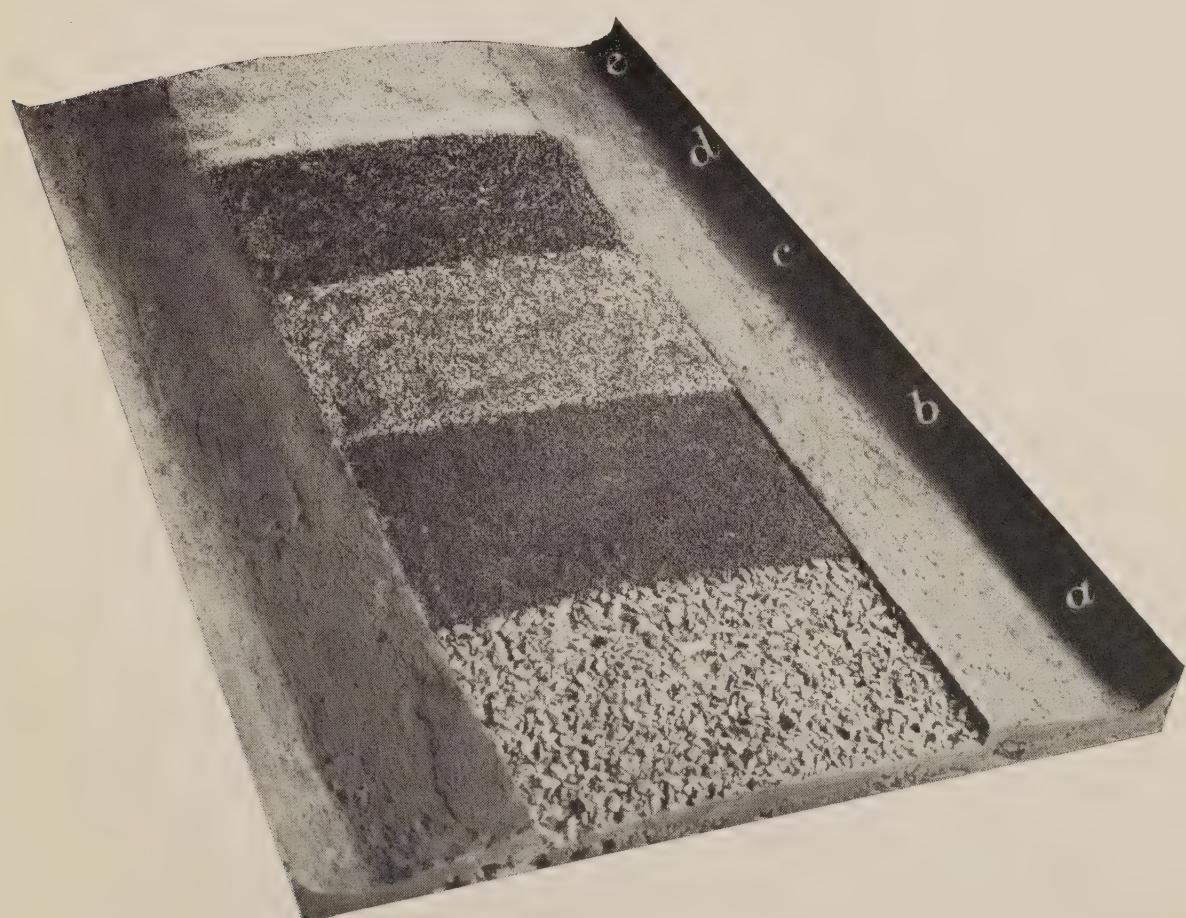


FIG. 2.—MODEL OF TARRED MACADAM ROAD—GLADWELL METHOD.

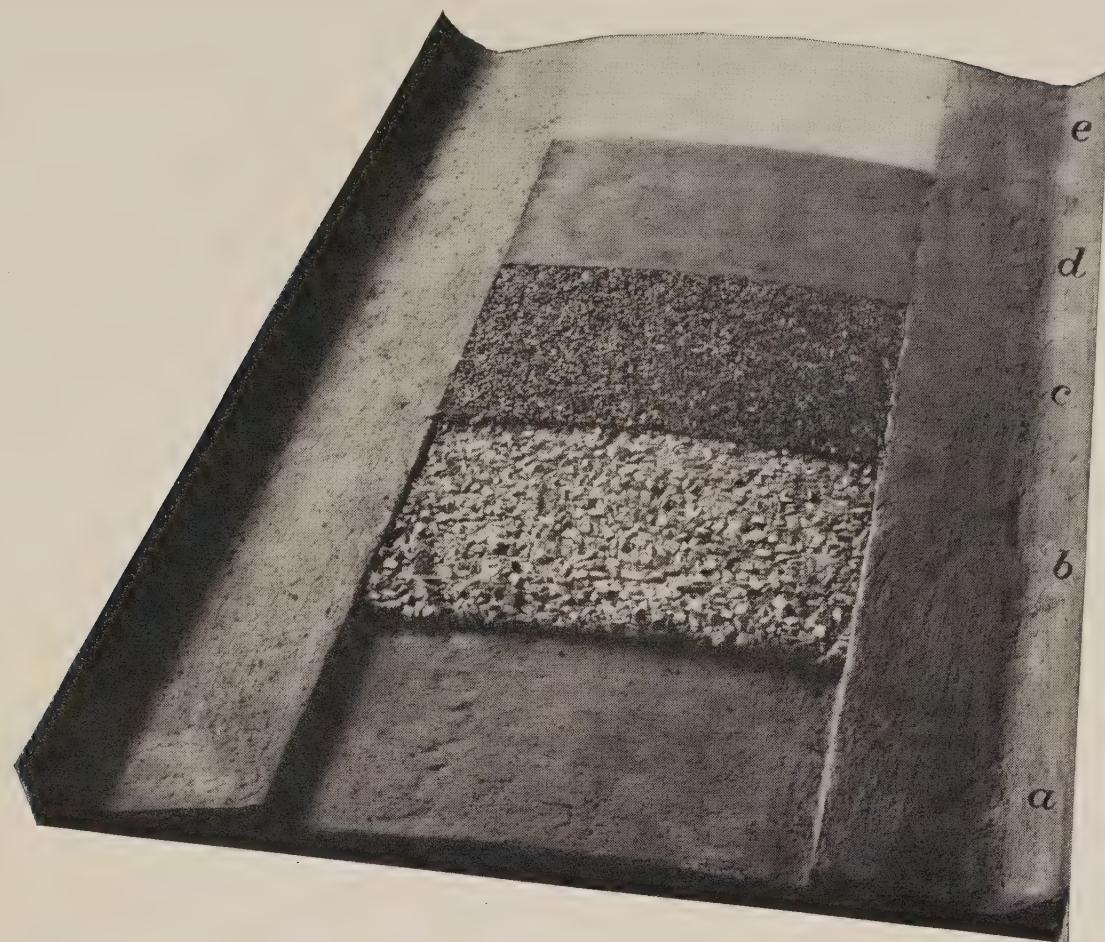


FIG. 1.—MODEL OF SAND-BITUMINOUS MACADAM ROAD.

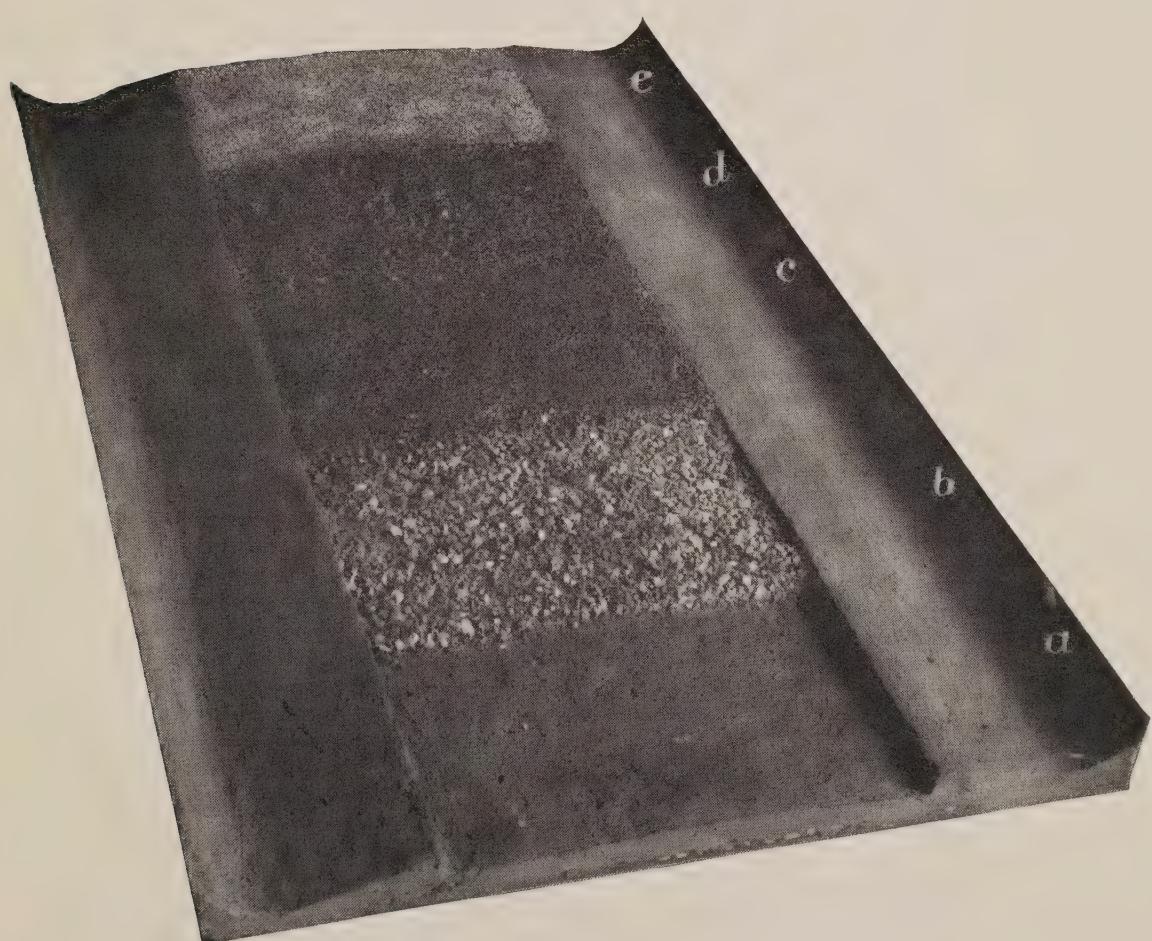


FIG. 2.—MODEL OF TAR-SLAG MACADAM ROAD.

Exhibit Office of Public Roads, U. S. Dept. of Agr., 1909.

PLATE XII.

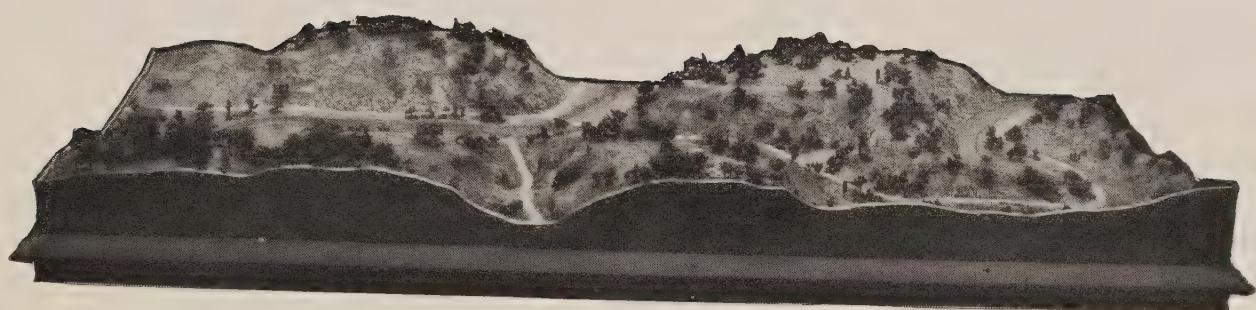


FIG. 1.—MODEL OF SECTION OF ROCK CREEK PARK, DISTRICT OF COLUMBIA.

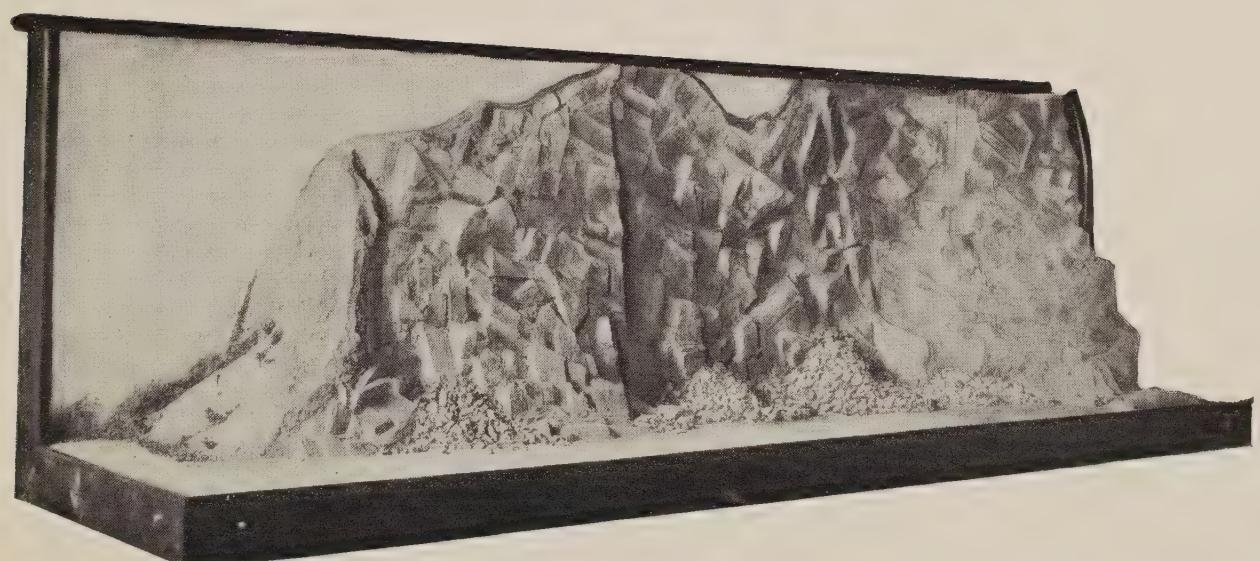


FIG. 2.—MODEL OF QUARRY.

The model is on the scale of 1 inch to 20 feet, and it represents a rectangle about 1,000 feet wide and 2,500 feet long. The highways which cut the park are splendid examples of the road-builder's art, the grades being easy and the roadbeds being surfaced with trap rock of the best quality. Bowlder Bridge and Pebble Bridge, which are shown in the model, are picturesque ornaments, Bowlder Bridge, which fits harmoniously into the scene, being especially attractive in coloring, as it was constructed from bowlders picked from the bed of the stream.

Of all its attractive features, visitors to Rock Creek Park will find none more pleasing than the section of road which runs past Pierce's old vine-covered mill with its broken wheel and shimmering mill pond. For 7 miles this road follows the tortuous windings of Rock Creek, each twist and turn revealing a new vista of wild and picturesque beauty.

Passing from the gorge through which the stream flows, this road branches into others, which by slight detours and gentle inclines lead to high plateaus from which the stately Capitol may be seen in the distance.

ROAD MACHINERY.

CRUSHING PLANTS.

This model (fig. 1) represents a portable stone-crushing plant, an indispensable adjunct to the building of first-class stone roads, for if such work is to be well and cheaply done, it follows that the plant must be complete and conveniently arranged.

When possible the crusher should be so near the quarry that the rock may be sent down grade in tram cars and delivered to the crusher's mouth by gravity, thus rendering lifting it by hand unnecessary. The crusher should be provided with an elevator and with screens for separating the material into proper sizes. The screens should be divided so that through the section near the upper end fragments not exceeding one-half inch will pass, the second section allowing the passage of stones of $1\frac{1}{4}$ inches, and the third section permitting stones $2\frac{1}{2}$ inches to make their way. Any larger stones will be forced through the open end of the screen, from which they will drop into the tailings conveyor, being finally crushed or eliminated from the work. The jaws of the crusher should be set so as to make as few tailings as possible, and the lengths of the screen sections should be adjusted to the same purpose.

When soft stones are being crushed a dust jacket, having one-half inch mesh, may be placed over the first section to eliminate dust from the screenings.

For receiving the various sizes of crushed rock, bins with slanting metal bottoms and sliding doors should be provided, so that the material can be loaded into wagons by gravity.

Two types of crusher are now commonly used, one the jaw crusher, as shown in figure 1, and the gyratory crusher. The jaw crusher is generally used for portable plants.

In this machine one of the jaws moves backward and forward by means of a toggle joint and an eccentric, the stone descending as the jaw recedes. As it returns, it catches the stone and crushes it. The

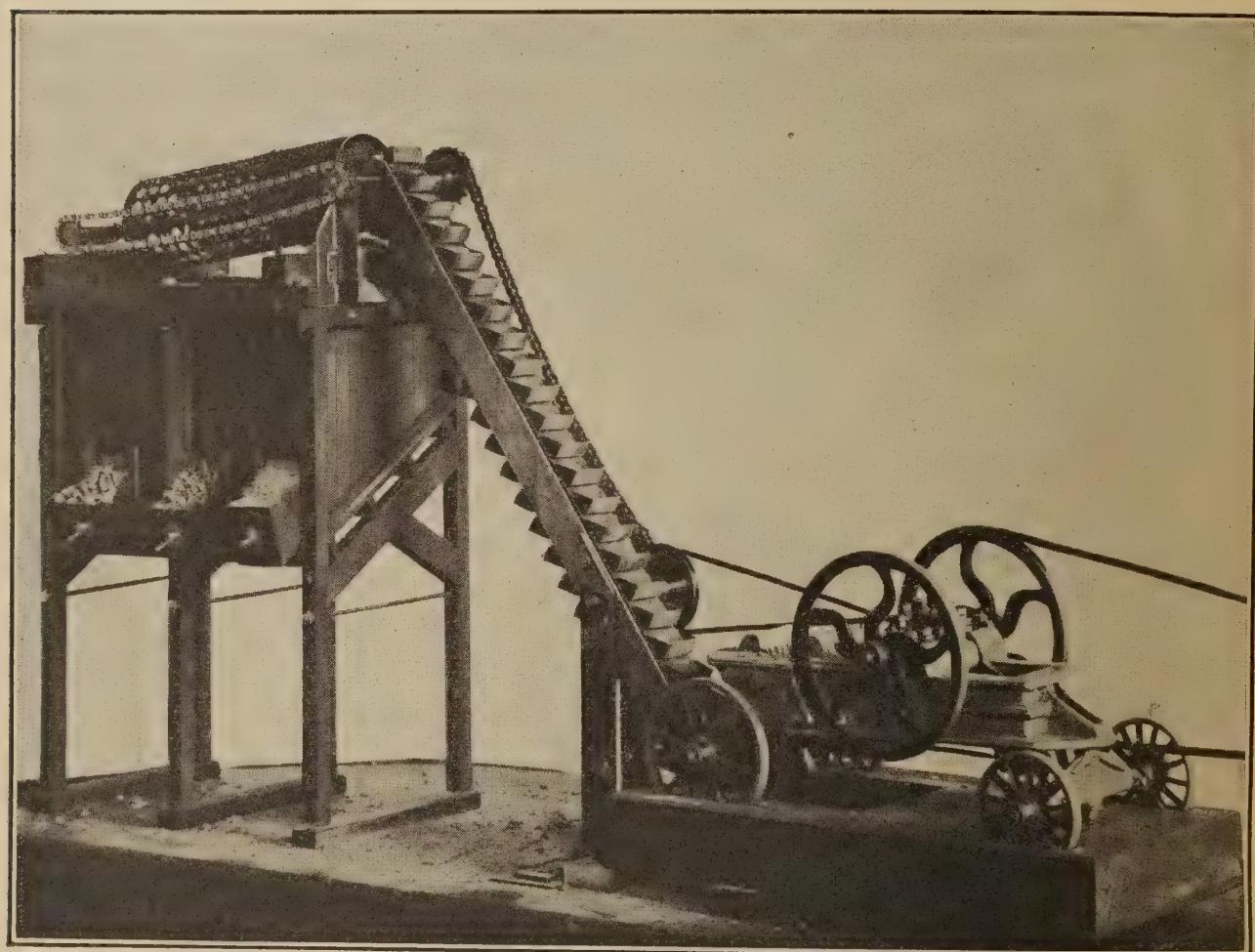


FIG. 1.—Exact model of portable crushing plant in operation.

maximum size of the product is determined by the distance the jaw plates are apart at the lower edge.

The gyratory crusher consists of a solid conical iron shaft, supported with a heavy mass somewhat like an inverted bell. By means of an eccentric a rotary motion is given the shaft so that every point of its surface is successively brought near the surface of the "bell," the rock caught between shaft and bell being crushed.

The gyratory crusher will not produce as many flat pieces or tailings as the jaw crusher, because the stones have to come in contact with two curved surfaces at the same time before they are broken.

WHEELED SCRAPERS.

This model (fig. 2) illustrates a wheeled scraper, which consists of a steel box mounted on wheels, provided with levers for raising, lowering, and dumping, all of these movements being made without stopping the team.

Wheeled scrapers are made in three sizes, having capacities of 9, 12, and 16 cubic feet, respectively. They are used in building earth roads, or in preparing the subgrade for macadam roads, especially

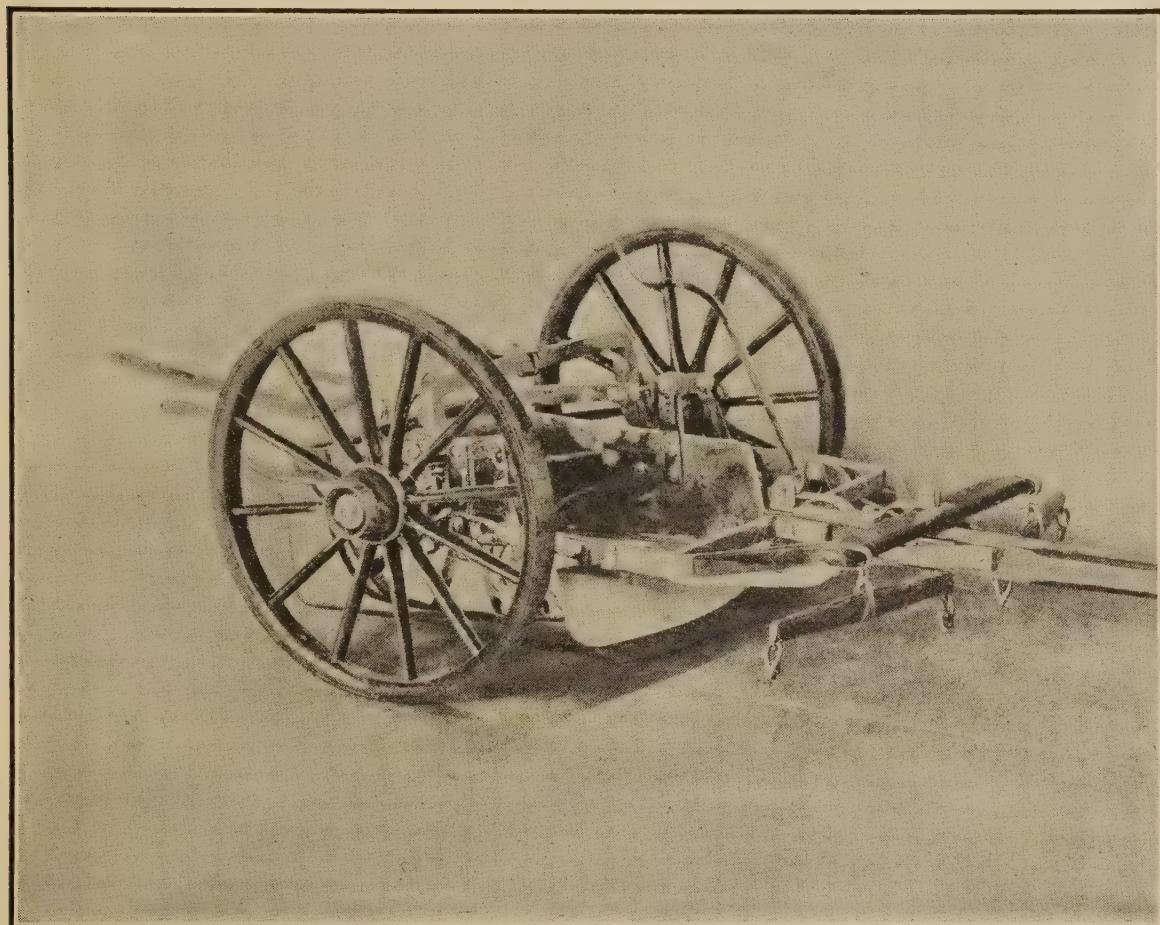


FIG. 2.—Exact model of wheeled road scraper.

where cuts and fills are to be made and where the material can not be conveniently handled with drag scrapers.

ROAD MACHINES OR GRADERS.

This model (fig. 3) shows in miniature a machine which is extensively used in building and in preparing the subgrade for macadam roads. As will be noted, it consists of a frame carried on wheels which support an adjustable scraper blade, the front end of which plows a furrow, while the rear end pushes the earth toward the center or distributes it smoothly. The blade may be set at any angle or tilted either backward or forward.

In building the earth road with the road machine a furrow is first plowed with the point of the blade where the outside of the ditch

is to be located. The blade may be made to penetrate hard or stony ground by elevating the rear end considerably and by using only the point of the blade for such plowing.

On the second round, with the front and rear wheels in line, the team should be driven so that the point of the blade will follow the furrow made by the first round, plowing a full furrow with the advance end of the blade and dropping the rear end somewhat lower than before.

When the third round is made the machine should be guided toward the middle of the road, thus shoving the earth previously plowed toward the center. This is done by slightly elevating the rear end of the blade to allow the earth to distribute under it and to give the necessary crown to the sides of the road. Three times

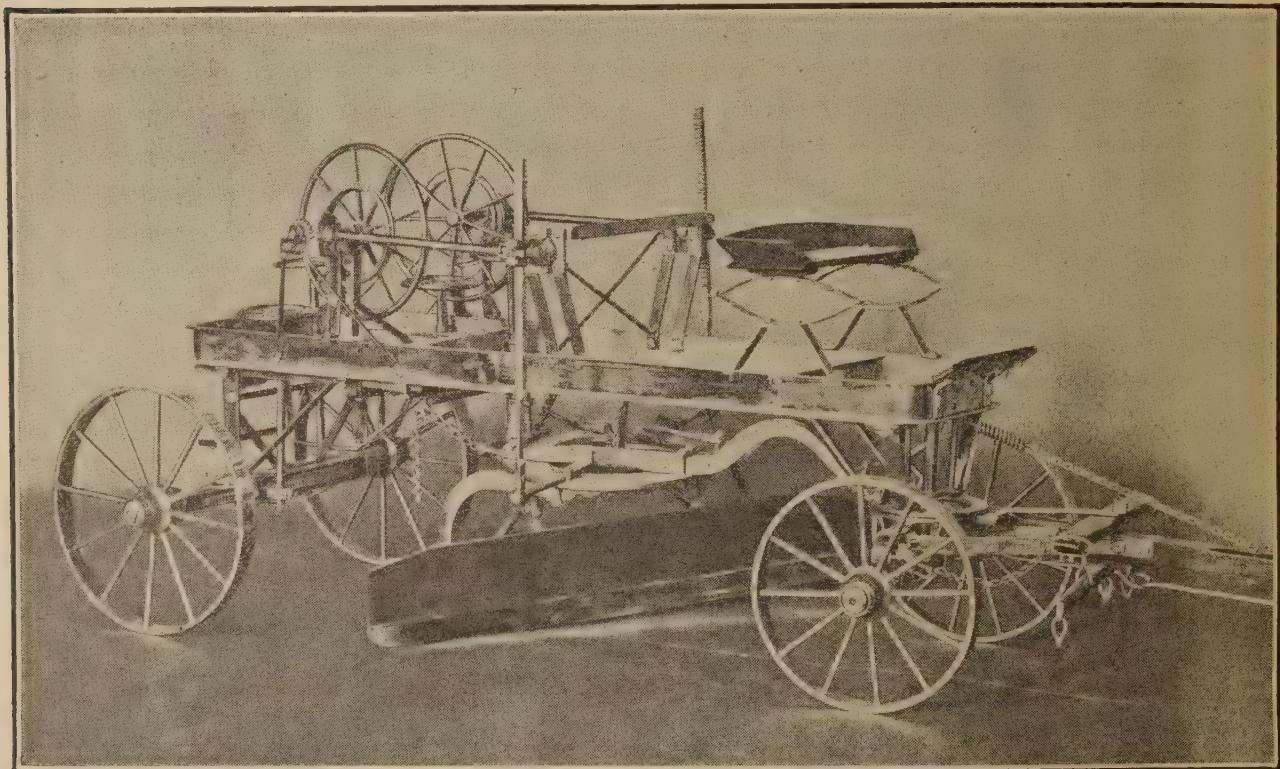


FIG. 3.—Exact model of road grader.

this operation should be repeated until three layers of earth have been moved to the road center, but care should be taken not to leave a ridge in the center.

It is advisable to use the machine when the ground is soft, the grading being done in the early summer when possible in order to give the loose earth time to settle and pack before the fall rains. If the work be done in the fall no more than 3 or 4 inches of loose earth should be put on at one working.

If the side of the road is covered with sod, this should be cut as thin as possible with the road machine and moved toward the center of the road, and the earth from the side ditches will then cover it to such a depth that it can not be objectionable.

From 4 to 6 inches of loose earth is sufficient for one working.

ELEVATING GRADERS.

Figure 4 shows a miniature of the elevating grader, which consists of a frame carried upon four wheels, the grading machinery consisting of a plow and a wide traveling belt, this latter being in sections and so adjusted that it may be raised or lowered.

The type of grader used in ordinary highway work will deliver earth 7 feet vertically and from 14 to 17 feet horizontally, the plow loosening the soil and passing it directly to the belt, which delivers it either to an embankment or to wagons.

By changing the length of the belt and properly distributing the earth the machine will build either a broad low embankment from a deep narrow cutting or a narrow high embankment from a broad shallow cutting.

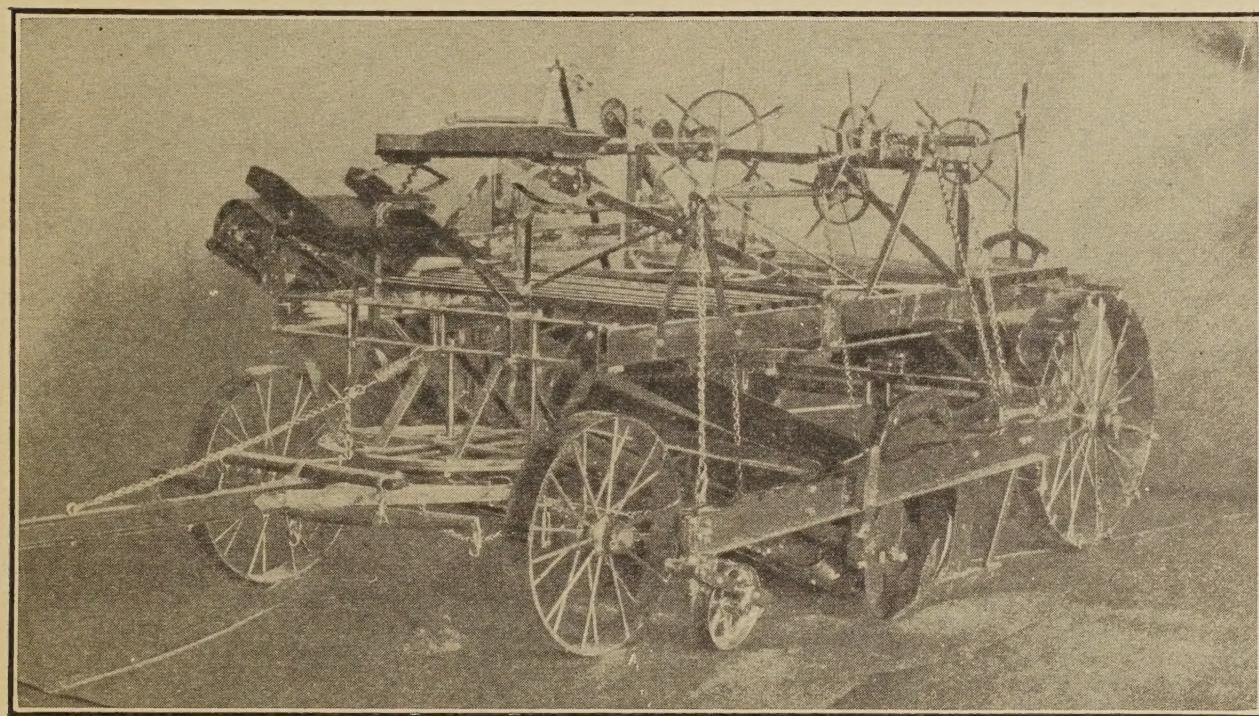


FIG. 4.—Exact model of elevating road grader.

This machine is especially adapted to building earth roads in prairie country or on flat lands where it is desirable to raise the road above the surrounding ground or the water table.

Like nearly all other machinery, the elevating grader comes in various sizes, the largest usually being propelled by 12 horses, 8 pulling and 4 pushing. The smaller one, which is generally used, is operated by 8 horses. A traction engine may be used instead of horses, and it will be found to be cheaper.

In building roads or embankments this machine has a capacity of about 1,000 cubic yards each ten hours and about 600 yards when loading into wagons. It will grade about a quarter of a mile of ordinary prairie road per day to a width of 25 to 30 feet with a depth of 1 foot in the center.

